OUT OF THE NIGHT

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A Biologist's View of the Future

by

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PREFACE

THE MAIN BIOLOGICAL VIEWS in the present volume were contained in a manuscript, " Revelations of Biology and Their Significance," read before the Peithologian Society, a small student organisation at Columbia University, in 1910. The volume in practically its present shape (with the exception of Section VI) was prepared in 1925; part of it was presented as a public lecture entitled " The Promise of Biology," at the University of Texas in the spring of that year, and all of it at the University of Chicago under the title " A Biologist's View of Progress " in the summer of the same year. Aside from the addition of Section VI and a few minor expansions in Sections IV and VII, virtually no alterations have been made since then, as it was thought of greater interest to allow the original passages to stand checked, so far as possible, by the subsequent progress of events. Many of the passages, if written to-day, could have been made considerably stronger and more concrete. However, the treatment is sufficiently modern, I believe, to pass

muster despite recent progress in physical and biological sciences, and changes in social conditions, and despite the fact that some of the contentions put forward are now more generally conceded. The withholding of publication until the present time was intentional and, in my opinion, has proved to have been advisable.

Apologies should perhaps be offered for the fact that, since this book was written from the point of view of one trained primarily in biological science, attention has been largely limited to those factors which have a fairly close relation to this field. Thus, for instance, the logical connection between Darwinian theory and the general intellectual changes of modern times has been stated in the second chapter, but the basic rôle played in this same intellectual revolution by fundamental alterations in economic conditions, and by the correlative rise of Marxian theory, is only touched upon. A more complete synthesis is invited. Admitting this, however, it is interesting to note that the development of these different lines of thought led logically towards the same conclusions.

Since the original writing of the present work, a part of the ideas contained have been expressed in a number of books published a few years ago, notable among which is the series including *Dædalus*, *Icarus*, *Tantalus*, *Hymen*, etc. Although

sharing some views with these books, the present work, taken as a whole, represents a somewhat different general attitude from any of them. The first important difference, which is also the central theme of the present book, lies in the attempt to show that for a continuance of material, cultural, and biological progress in the human race, a thoroughgoing economic and social change to a more truly co-operative basis of society, together with the regeneration in human motivation attendant upon this, is a prior necessity. The great depression which has settled down upon the western world since the original preparation of the present manuscript has in the past six years been bringing the need of such a reorganisation directly home to multitudes who had not yet realised it, and even scientists are at last beginning to recognise the bearing of these things on their own work. The best illustration we may cite here is the illuminating treatment of this subject in the little volume, *The Frustration of Science* (George Allen & Unwin, Ltd., 1935) by a group of British scientists, which has just come to hand as this goes to press. The reader who is interested in the subject matter of our Sections III and IV may be referred to this symposium for far more concrete and adequate treatments of largely the same themes.

In the meantime, our airy imaginings concerning the future possibilities of co-operative activity on a grand scale are brought down to earth and given substance when we turn to the great and solid actualities of collective achievement which are becoming increasingly evident in that one section of the world—the Soviet Union—in which the fundamental changes in the economic basis have already been established. More intimate familiarity with these developments at the time of writing would have rendered available a mass of material pertinent to our subjects. There the march of progress proceeds apace, while elsewhere discouragement and decadence admittedly deepen. This central fact of the present-day social world at once substantiates and belittles our theorisings.

The second chief point of difference between the present volume and earlier treatments of biological and other progress lies in the far greater amount of stress laid on the possibility of positive biological improvement of mankind, *provided* the social reconstruction occurs first. I have carefully considered this problem from the genetic point of view, and have come to the reasoned conclusion that all previous serious estimates of the amount of genetic change that would be possible and desirable for man have been too

utterly modest, as have also been previous notions of the speed (or lack of it) with which such changes can be brought about. But in order to carry out these larger ends new methods will have to be employed, methods largely known already, and new ideals set up, as explained in Section VII; neither these methods nor these ideals can find an approved and adequate place within the present organisation of society. In these conclusions I no longer stand alone among biologists or geneticists, although I did seem to be alone when I first expressed these ideas some years ago.

It is particularly gratifying to be able to add here—after sending this book to press and immediately before its publication—that there has just appeared in the *Eugenics Review* a striking article by Herbert Brewer, entitled "Eutelegenesis," in which the same biological methods are advocated as those presented in my Section VII. I am glad to state my unqualified approval of Brewer's general thesis so far as the biological side is concerned; and I am especially pleased also to learn that a number of leaders of modern thought are already showing a favourable interest in the matter at issue. Nevertheless, I must here reiterate that, in capitalist society, the proposed undertaking is to be thought of only as an experiment, and (as explained in what follows) an

experiment that would be foredoomed to ultimate disaster if it were long continued under anything like present conditions. Brewer writes me that he quite realises the justice of this stricture. Meanwhile, it may of course be contended that the experiment as such can be highly instructive, as a preparation and a lesson for a more effective later attack in more auspicious social circumstances and with better methods of selection, and that it is quite likely that the present unfavourable social conditions may not continue so long as to result in a serious confounding of the main objective. This remains to be seen.

But despite the cases of agreement referred to above, I realise that I am bound to meet the opposition of most professional eugenists of the stereotyped school that at present (as an outgrowth of modern social conditions) is in the ascendancy in this as yet semi-scientific subject. In fact, it may be admitted that " Eugenics," in the sense in which most of us are now accustomed to thinking of it, has become a hopelessly perverted movement. Beyond imposing some slight limitation on the numbers of the most grossly defective, it would be, with its present methods and outlook, powerless to work any positive change for the good. On the other hand, it does incalculable harm by lending a false appearance

of scientific basis to advocates of race and class prejudice, defenders of vested interests of church and state, Fascists, Hitlerites and reactionaries generally. Even the least unreasonable of the professional spokesmen of this modern "Eugenics" have taken no clear stand against the atrocities recently proposed and carried out in its name.

Thus it is high time for those who seek the real biological upbuilding of humanity to repudiate this perverted kind of "Eugenics," and to devote themselves to furthering the economic, social, and intellectual changes which alone will afford the means of eventually undertaking a real biological upbuilding. At the same time, those already engaged in the social struggle may gain some additional stimulus in noting the dependence of even the biological battle upon their efforts.

H. J. MULLER

September 1935

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I

HOW HAS MAN BEEN MADE ?

OUR IDEAS of what sort of progress is possible or desirable for man must depend in part at least upon our views of his nature, his manner of origination, the methods by which changes have occurred and can occur in him, and the relation which he bears to the rest of nature. It is a commonplace that these questions have, within the past two-thirds of a century, been thrown into an utterly new light—and an ever clearer one—by the findings of biology, supplemented by those of physical science. Yet there are a number of serious misconceptions afoot (even in semi-scientific circles) regarding the essential trends of the more recent biological work. It is, for instance, whispered, and later shouted, that "Darwinism is dead," that "materialism has proven inadequate," or that "acquired characters *are* inherited after all." And upon these fallacies are founded various spurious philosophies of life that profess to answer

for us the questions "whence," "why," and "whither." The reader will see, therefore, that before we may consider fairly the topic of progress itself, we must pass briefly in review, in their most modern setting, the salient features of the basic biological principles therein involved. Indeed, a thoroughgoing recognition of these truths will itself carry with it a radical re-creation of our outlook upon human life, and, by the same token, it is to the interest of reactionaries everywhere (both in and out of science) to warp, to deny, or to belittle them.

In the establishment of these broader generalisations the earliest fruits of victory fell, as is well known, to the comparative anatomists. They showed beyond all doubt that in every discernible portion of his structure man is but an animal, no different in his inherent nature from other animals. It is true that in this conclusion their careful studies of morphology have merely corroborated at great length the casual observations which men in all times must have made, for it must have been obvious to anyone that, superficially at least, the differences separating a "higher" animal (such as a dog) from one of another grand division (such as an oyster or a sponge) are far greater than those separating any higher animal from man. The embryologists

—naturalists of a somewhat more prying disposition—have added that this similarity between man and other animals extends, with even greater distinctness, to the development of all the parts from the egg. More recently the bio-chemists, immunologists, physiologists, psychologists, and other experimental workers, in a vast array of investigations, have come to the same conclusion with regard to the chemical composition and all the intricate workings of the elaborate organisations of man and beasts. And the searchers through the microscope confirm the finding for all essential features of the finest visible components, so far as microscopic eye can see.

I have only to look among the discoveries of those who have lately been my immediate colleagues to find striking new discoveries of the sort in question. So, for instance, Hartman, in tracing the details of the female sexual cycle in mammals of various kinds, and the significance of these details, finds that the course of the sexual processes in the monkey *Macacus*, while basically derivable from the series of physiological events occurring in mammals in general, involves several important departures the meaning of which has been misinterpreted and which together result in a very different-seeming ensemble from that in other mammals; and that

quite these same peculiarities and ensemble, down to the exact number of days occupied by the cycle, are to be found also in man. Again, my colleague Painter not long ago discovered that in man the chromosomes—the minute bearers of heredity—number 48; that in the monkeys of the Old World group (which in many respects more nearly resemble man) the number is the same; but that in the lower monkeys (which occur in the New World) the number is 54. Thus in this intimate and, in a sense, unnecessary detail man comes even closer to the African monkeys than the American monkeys do. These, however, are but recently adduced instances of significant correspondence in the whole great system of complexly organised structures and processes, all of which illustrate the same principle. Taking all the evidence together, there can be no question that man belongs as rightly in the system with the animals as do any of the other animals – themselves.

Now it is generally recognised by biologists that the workings of all the gross parts of animals —such as the liver, muscles, brain, etc.—and also the workings of plant parts, are entirely due to the reactions and interactions of the finer, microscopic units—the cells—of which all gross parts are composed. Beyond this, modern

experimental and microscopic science is bringing forward striking evidence that all the operations of these cells are the resultant of the actions and interactions of still smaller particles within the cells—such as the "genes" of the "chromosomes," the "mitochondria," "Golgi bodies," etc., as well as even more finely distributed and dissolved substances. And, according to the students of cell physiology, there seems no good reason to doubt that these constituent particles in turn, which are at or beyond the limits of microscopic vision, are formed of a complex system of what the physical chemists call "colloidal" bodies, and owe their entire behaviour to the changes and movements which the latter undergo, in their reactions with each other and with the dissolved substances lying about them. The colloidal bodies and the dissolved substances are necessarily beyond the range of the microscope, but they are certainly composed of the molecules of chemistry, and their properties depend upon the nature of these molecules and the manner in which the latter are combined. As the molecules are made up of atoms of familiar type, most complexly arranged and yet apparently not violating the laws of chemical combination, it appears as though all living things consisted, in the last analysis, of a superlatively

complicated organisation of atoms, in which each individual atom is identical with the atoms of inorganic substances and works wholly according to the same laws. The seemingly miraculous attributes of living things, such as their powers of growth, reproduction, compensation, regeneration, sense reception, nerve and muscle responses, mind, etc.—in a word, "adaptation"—could then be referable, not to any extraordinary characteristics of their atoms in particular, nor to the intrusion of any mysterious "vital force" or new entity at any stage, but rather to the marvellously orderly complication in which the atoms of living matter are arranged, so as to form a stupendously intricate structure of harmoniously interacting parts.

The shortcoming of the early "mechanists" lay in their failure to realise sufficiently the transcendent complexity and the interwoven character of the life fabric, and the rôle played in its determination by a virtually infinite series of remote and involved historical processes. Compared with a living human cell, the mechanism of the most delicate chronometer is perhaps as coarse and simple as is the mechanism of a crowbar when compared with the chronometer itself. And we are composed of many trillions of cells of manifold types, put together in highly

special ways. How fine and intricate the organisation within an individual cell may be is best realised by thinking of the fact that in development an entire man (or other animal) automatically shapes itself, and grows, from a single cell (the fertilised egg cell), which therefore contains within itself the entire "machinery" to build a man—and that nevertheless the egg cell is itself so tiny that if we could collect together all the human eggs now existing which are going to form the next generation of mankind—two thousands of millions in number—we could pack them into a one-gallon pitcher! And all the fertilising sperm cells, which equally with the egg cells determine the hereditary traits, would occupy only about half the amount of space of an ordinary aspirin tablet! As a matter of fact, the actual hereditary substance in the eggs would occupy only the same amount of space as the sperm; hence the hereditary substance of both eggs and sperm together would form just one tablet of the size of an aspirin tablet. It is hard to realise that in this amount of physical space there now actually lie all the inheritable structures for determining and for causing the production of all the multitudinous characteristics of each individual person of the whole future world population. Only, of course, this

little mass of leaven to-day is scattered over the face of the earth in several billion separate bits. Surely, then, this cell-substance is incomparably more intricate, as well as more portentous, than anything else on this earth.

It is thus evident that before we can properly understand the living things of our world we must first learn to know the structure of that new world-of-the-small which within the past few decades has been opened to the mind of man. At first sight the attainment of such knowledge seems a fantastic dream, but modern genetics is already beginning to invade the ultra-microscopic land inside the eggs and sperm cells of the fly *Drosophila* and of some other forms of life; and to bring back from this survey what we actually call "maps," on which are shown, within the chromosomes of an individual germ cell, the locations of hundreds of the separate hereditary particles or "genes" that help to determine the various visible characters of the individual growing from that germ cell. After all, the latter—though tremendously more complicated—is by no means so minute a mechanism as that with which the inorganic chemist works. To gain adequate control over the world of things of our own size, then, we must first seek knowledge and control of the very small world.

The same conclusion is being reached to-day, with equally great force, in the realms of inorganic chemistry and of physics. And surely we cannot hope to conquer successfully the great masses in the sphere of very large things until we have control over those of our own size. The precept therefore follows that, for man, the road to the macrocosm lies through the microcosm.

Concerning the manner of origin of this staggeringly involved fabric of organic nature, all its features bear witness, and countless secondary tokens testify, that it has arisen most gradually through the operation of natural forces no different in kind from those which are working within it to-day, and which are ultimately referable to the mode of combination of its atoms.

For many millions of years blind chemical forces must have acted and interacted in early times to build up ever different and more complicated organic compounds and systems of compounds; but a turning point was reached when from these shifting combinations those materials which we call "genes" happened to become formed. Genes are self-propagating—that is, growing, multiplying particles within the organic system, which may by their chemical activity

affect the characteristics of the system in all sorts of ways: its chemical properties, its shape, its size, its internal and external structure (fine and gross), and its behaviour. The genes are themselves subject to occasional internal chemical alterations, or " mutations," which do not deprive them of their power to grow but do change the nature of their action upon the system. From the time of the birth of these mutable genes onward, the different genes (or the little systems of organic matter containing an association of genes) would necessarily enter into a destructive competition for growth and multiplication against each other. Relatively few of all that were produced in the multiplication process would now be able to survive, and to increase still further; indeed this would occur only in the case of those rare ones in which mutations had happened to result in genes whose action was especially favourable for the growth and multiplication of the gene itself and of the organic system (or " protoplasm ") containing it. The other organic corpuscles, containing genes that had not mutated, or that had mutated in ways unfavourable to their growth, were meanwhile weeded out. By the repetition of these events, times without number, a more and more complexly efficient organisation became built up within

those protoplasmic masses which did manage to persist and multiply. So, step by step, through mutation (the alteration of genes) and heredity (the multiplication of genes) the millions of marvellously fashioned species of animals and plants which now exist were differentiated and integrated.[1]

It should be distinctly realised that, in all of this, there is no evidence of an internal principle in organic nature causing beneficial, adaptive, admirable, or desirable changes to occur, rather than deleterious ones. In fact, the author has found that in the flies the harmful mutations far outnumber the beneficial ones, and this finding is being confirmed in other organisms. Thus, in spite of the great preponderance of detrimental variations, what we call progress ensues in the end, simply because, as Darwin pointed out (and we are not overthrowing Darwin in modern biology, but rather are building ever higher upon the basis that he laid down), the harmful variants perish in the struggle, whereas the accidentally beneficial ones survive. As this happens repeatedly, beneficial characters accumulate in the race. But we can see here that immeasurably more germ plasms finally die

[1] Most of the material in the above paragraph was used with little change in the author's article "The Method of Evolution" in *The Scientific Monthly*, Vol. 29, 1929, pp. 481–505.

than manage to continue, and we owe all our wonderful frame to the cruelty of nature, which from step to step allowed the animals carrying our ancestral genes to multiply only at the cost of a life-and-death struggle in which the others, usually the vast majority, finally perished miserably.

Note, then, that though the evolutionary process may be described as a "progress" in complexity or adaptation, it does not necessarily result in an increase in the well-being or the happiness of the competing individuals, because it provides all survivors with increasingly deadly weapons in a great world war that not only pits species against species, but still more makes the individuals of the same species (in some cases, of different groups of the species) competitors of each other. The latest upstart, man, has been able partly to thwart this tendency only because, along with other advances, he has succeeded to some extent in limiting the growth of his naturally slow-breeding population, and in temporarily and occasionally amplifying his means of subsistence faster than his population has grown. Note also that although the creatures which were allowed to survive in any given age were those which happened, at that time, to fit, this did not by any means imply that they would be

found to fit in the long run. Every germ plasm, every species, including man, is still thus on probation; and if—as much more often happens—it does not chance to have (or to acquire by mutation) genes so useful as those of the best competing species, it is eventually snuffed out ruthlessly.

Now this peculiar creature, man, has as yet had only a very short probationary period. Recent findings in radio-active rocks have given testimony that the entire process of organic evolution on the earth has taken something like a thousand million years, at least—possibly even several times as long. Only by comparisons can we grasp such immensities, so let us imagine this period symbolised by a distance along a cord, each yard of which stands for 10,000 years, and which ends, in the present time, at some established point of reference—say the centre of the private desk of J. P. Morgan in his office in Wall Street, New York City. To represent the beginning of organic evolution we should have to start the string many miles away—probably at least as far off as New Haven, possibly as far as Boston.

It is of interest to note that, on this scale, a human generation (from one birth to the next) would occupy somewhat less than an eighth of an inch, and that, if our symbolic cord were taken

as about three-eighths of an inch wide (a small rope), the portion included within one generation would then be a disc-shaped cross-section having the approximate dimensions of an ordinary aspirin tablet. Now this is just equal to the volume of hereditary material which actually is contained in one generation of mankind, and which is to be passed on to the next generation (as explained on page 21). Hence our cord now acquires a further symbolic significance, in that it may be taken as representing in a certain real physical sense the evolving germ plasm of ourselves and our ancestors—though it would not everywhere be of equal width, as the numbers of the population change. Within this cord the fine fibres represent the chromosomes themselves, which are in fact filamentous bodies that intertwine, separate, and reunite in diverse ways as they pass along from generation to generation in the varying combinations resulting from sexual reproduction. In this cord, then, there would be represented, in one long line of ancestry, all the material which, from the beginning, has continued to make generation after generation of progressing forms.[1] Their bodies (or soma), which

[1] The representation breaks down to this extent: that even within one generation the germ material becomes renewed many times over by growth and division, the renewal in man being between ten and twenty-five times per generation; furthermore, in different species this

constituted a vastly greater volume, may be considered as a series of excrescences about the cord, formed under the influences emanating from the by-products of the cord's chemical activity. The evolutionary changes manifested in their multitudinous characteristics are but reflections of primary changes occurring within the potent particles (genes) composing the tiny filaments of the cord itself. While the cord in question shows our particular line of ancestry, the lines of the millions of other living species would be shown by other, parallel cords—some thin, some thick, some branching as time goes on and as species diverge from one another, and many coming to an early end as species become extinct; but practically all the "higher" forms, at any rate, tracing back their origin to one original cord in the beginning. At any given place there is but a single one, out of all the mass of cords, which has led on so as finally to issue in our branch; this may be distinguished, in our figurative representation, by giving it a red colour. It is this red cord which may be regarded as the red "thread of destiny," in a rather literal sense. Its free end is even now being spun further, being transfigured by mutation, being twined and interwoven, to

renewal rate is different and the number of generations in a given time varies greatly. These discrepancies could be remedied by appropriate changes in the lengths of the cords.

give a new sort of living world, dependent on its new properties.

Let us now start at the beginning of the mass of life cords—say at New Haven—and follow along them on their long way towards their present destination in New York City, observing what forms are assumed by their bodily outgrowths (soma) as we travel forward. Except to the trained biologist, it will prove a dreary trip for much the greater part of the distance. For in this whole journey there will be no actual " beasts " as we ordinarily think of them (four-footed land animals) until we are well within the limits of New York City. Not until we are passing through Harlem shall we see any creatures with fur or feathers—i.e., mammals or birds. And note that even at that stage in our journey tremendous reptiles—dinosaurs—are still crashing over the earth; they long remain dominant over the few little warm-blooded pioneers, and they do not disappear until after we cross Forty-second Street. Not far below that point monkeys make their first appearance; but from that point southward the records show nothing higher than an ape until, having turned the corner of Wall Street, we actually confront our terminal building. There, about one hundred feet from the end of the cord, are found the relics of the famous " missing link "

—Pithecanthropus—not yet a man, but passed beyond the ape. Well within the building, and only about fifteen feet from the desk in question, stands that stoop-shouldered lowbrow, the Neanderthal man, whom we do not dignify by classification in our species—the species self-styled *Homo sapiens*, "man the wise."

Our own *Homo sapiens* leaves his first known remains within the private office, only seven and a half feet from the desk. The earliest known "civilisation" (not over 14,000 years ago, according to maximum estimates) leaves its crockery a yard and a half from the desk. On the desk, one foot from the centre, stands old King Tut. Five and a half inches from the centre we mark the Fall of Rome and the beginning of the Dark Ages. Only one and a half inches from the present end of the cord come the discovery o America and the promulgation of the Copr nican theory—through which man opens his for the first time to the vastness of the wo which he lives and to his own relative ir cance. Half an inch from the end of the c start the first faint reverberations of the Revolution, which set this desk here is now completely transforming m existence. A quarter of an inch Darwin speaks, and man awakes

character of his shape and his institutions.

Since we men are, in our present forms, such recent comers upon the battlefield of the earth, what are the characteristics that have made us successful in so short a time as all this indicates? The answer is clear: the combination of intelligence and social behaviour—or, we may say, of cunning and co-operation—whose product is "tradition." Man cannot outrun, outbite, or outclaw the animals; but, making tools and traps, he can outwit them. His native intelligence, to be sure, is neither different in kind nor many times greater than that of some other animals. Individually and untaught, he scarcely has the wits to fashion the simplest tools. There seems to be needed a fairly definite critical amount of intelligence (and possibly of the impulse to imitate) before numerous experiences and customs are turally transferred from one animal to another.

was the first animal—at least the first *rious* animal—to just overstep this critical f intelligence. Accordingly, since he does social impulse to band with others of one little happy discovery after another, ht beneficial modification of usage— upon by the most intelligent—has long from man to man, and from in the progress of the ages, till

finally the average individual's cranium carries packed within it the fruit of the combined experiences of many generations of the most superior meddlers and tinkerers—engrafted in it not by heredity at all (since there is no inheritance of acquired characters), but by that usually informal kind of education called "tradition." This process of accumulating tradition we call "social evolution."

Among the important useful traditions that in this way accumulated gradually among early men were language (which was especially important in accumulating more tradition and for which a special gift was needed), the processes of making and using implements, the customs in regard to fire, food, bodily covering where necessary, and shelter, and moral codes. And so, in spite of a concomitant load of disadvantageous traditions—some of them derived from useful traditions that became outworn or perverted, others doubtless based on misconceptions from the start—it has happened that the not excessive intelligence of man has, after numberless generations (though, geologically speaking, in an extremely short time), been multiplied to far beyond its native magnitude, thus "artificially" setting the capabilities of most groups of man at an immeasurable distance above those of the cleverest animals and enabling him to dominate the earth.

II

EVOLUTION
A REVOLUTIONARY DOCTRINE

IT IS NOT STRANGE that this array of concepts so recently gleaned—as well as their earlier and less perfectly apprehended versions—should have had a large part in causing the complete overturn which has occurred within the past century in all the philosophical and social sciences, inasmuch as these sciences were all based upon certain suppositions concerning the essential nature of man and his ways, and his permanent, stable, and central position in the " scheme of things." Thus psychology, having learned that mind is one of the modes of functioning of the body, is rapidly taking the position of an important and special branch of physiology—a place much like that which organic chemistry occupies in chemistry. Philosophy, invaded through the gates of psychology by the new knowledge concerning mind, broken into through the decaying ramparts of vitalism by the results of experiments

on living matter, and visited from above through the airways of ethics and metaphysics by the discovery of evolution and its mechanism—philosophy at first shrank violently back, and now is undergoing a metamorphosis in which a new unity of structure is gradually emerging, built upon girders penetrating into it from without. Anthropology, in its true sense, was born with the discovery of the "descent of man," and is at present going through a severe internal struggle over the question of how the principles of evolution may be applied to it. Sociology, history, economics, politics, are still writhing in the pangs of transformation to which they are subjected by the co-ordinate theories of biological evolution and the economic interpretation of history. This lag in reconstruction of the social sciences is due to their close connection with the system of production and distribution. For it is these subjects which have been made to furnish the direct ideological basis for justifying all established social practices. Hence those with interests vested in these practices use every possible means—from spurious argument to outright physical force—to oppose the change in social theory logically following from the newer knowledge.

Since, however, a change in theory in the social sciences was obviously bound to come, the

attempt was soon made to adapt the new theories to the practices demanded by the prevailing economics. Thus we find that at first the discovery of natural selection was used by Spencer, Nietzsche, and others in support of various existing or projected malpractices, on the ground that customs which intensified the struggle for existence furthered the survival of the fittest and progress. As we shall see later, it now appears that social struggle *under our modern civilisation* does not lead to the reproductive survival of the germ plasm most useful to the species. Moreover, as Kropotkin first well showed, co-operation (though not infallible) is a higher precept of evolution than is universal competition. Either of these opposed schools, however, must now accept the fact of change, of social evolution itself, since this follows as a necessary consequence from the fact that man has ascended from an ape-like level. During the same period the Industrial Revolution of the 18th and the 19th centuries was forcing men to the same conclusion. Before that time, the very idea of continued fundamental change in human institutions, and of the possibility of progress—the central idea now of the social sciences—was practically unrecognised. True, there had been foreshadowings of it in the writings of some of the more learned ancients; but these had had little

following. Thus into an inanimate body of scholastic doctrine has finally come the breath of life.

Even literature, with its inherited preoccupations, by no means completely escaped the general perturbation. The effect of the newer knowledge on it has as yet consisted chiefly in an indirect reflection upon its moods—to be referred to subsequently—rather than in a change in detailed intellectual content; but the time is coming when the true literary man cannot afford to remain aloof from the thought and knowledge of this age, else he will be unable to write of the real world in which men of modern outlook think, dwell, and have their being. He will degenerate into an acrobat amusing the ignorant, and his works will no more be heeded by thinking people, or able to satisfy their more extensive literary requirements, than the rambling tales of an Australian savage could meet the literary needs of the average city dweller of the present day after their tang of novelty had once worn off. The appalling paucity of concepts on the part of the average literary man of to-day, his blindness to the actual universe around him, is but one expression of the lack of education—or, more properly, of the miseducation—of the public in general in regard to essentials.

Rather than pursue in further detail the changes in viewpoint that have come about in various individual departments of learning, it will be more profitable to inquire: what must be the resultant effect upon man's general attitude and aims of the infiltration of the new knowledge throughout the domain of human thought? For the contributions of modern science discussed in the first section really cut through the formal subject-boundaries of the past, and their human import is striking.

A large part of the intellectual world, in reacting to the newly discovered truths, has gradually adopted an attitude of fundamental pessimism. For—we must not close our eyes to facts that seem disagreeable—there has occurred a shocking and wholesale destruction of values, cherished from time immemorial. Man's childish vanity has shrunk into the conception of himself as an animal, a mortal animal, one species among millions, floating on a ripple in an immeasurable ocean of time and change, between awful depths of space. Any single individual life, lived for itself alone, becomes as insignificant and transient in this expanse as a mote of dissolving dust. Our petty pleasures and pains, our separate ambitions and despairs, our hectic little businesses, lose meaning. We are engulfed, and life becomes only

a pathetic little journey to death in a universal vain struggle for existence. The horrible maladjustments following the Industrial Revolution made this struggle vivid to all but a few. Hence the pessimism and the cynicism which, in later Victorian times, found its way even into lighter literature. From the point of view of the individualistic economics and philosophy of that period, the findings of the science of the day were indeed abysmally discouraging. For not only was the individual life of the present thus robbed of dignity and significance; it also appeared that, by the only rule of the game then understood—a merciless natural selection—there was no prospect that happiness might be greatly increased in the future; whereas, without natural selection, it seemed there must ensue complete collapse. To cap the climax, the physicists proved that the earth must be slowly growing cold, and they laid down as an unconditional dictum their sonorous "second law of thermodynamics": that the energy of the entire universe, like that of a clock running down, is being dissipated little by little, approaching a state where all visible motion will cease.

So, in the sudden sight of the sun, has man stopped, blinded, paralysed, and afraid! But as the

flood of impinging energy gradually warms his being, and as his eyes become adjusted to the unaccustomed illumination, he distinguishes new shapes—unsuspected fields, paths, and summits, shining sunnily not far away. He discerns himself more clearly as a member of a close-knit band, which has, by its united efforts, already managed to advance a long way in the dark, but which now, in the light, can proceed with far greater joy, speed, and assurance. Even that bogey, the evaporation of energy, is showing some signs of turning into a cloud-shape of the dawn. And so our view changes, and we now see that, for the species as a whole (as the biologist looks at species), the possibilities are really unique and inexpressibly stirring. The recently innovated process of social evolution, confined to man alone, has enabled him to push himself up into an isolated position, fraught with potentialities barred to any other animal. And within a paltry few centuries this process has entered into an utterly unprecedented phase, which makes it incomparably more potent still. For in this phase man, and man alone, is acquiring the eyes of science wherewith to see the structure of nature and to guide his inventive hands towards the intelligent control both of the bit of cosmos immediately encompassing him and of that within himself. If he would continue to

raise himself, it must still be by his own efforts, but the productivity of his efforts is being indefinitely augmented. In terms of geological time, this extension of power is going on at an explosive speed, with a volcanic violence unparalleled in all past evolution; and the reaches to which its conquests may extend, a trivial thousand years from now, seem utterly beyond romance.

This way, then, lie escape, continuance, and perhaps a satisfying measure of victory. Not that power is in itself the only ultimate end for us, but the intelligent use of it helps to make possible real "progress" in the human sense—an increase in the amount of our happiness through the intensification and multiplication of the joys of life, and the enlargement and multiplication of lives of joy. In pursuing this course, man, as a species, is at the beginning of an adventure whose epic strains may ring down the corridors of the universe. It is true, as we shall see, that at the present time the already far-flung battle-lines of man are in a precarious condition behind the front. But the reason for this lies precisely in the fact that men have not yet adopted the attitude here set forth; their social organisation is so formed as to look in a different direction. So far as the individual man identifies himself with the struggle of his species, he may become indeed

great, and partake in a mighty continuance whose creations will satisfy the most exacting demands both of his egotism and of his benevolence. His individual acts, when brought in line with this triumphant trend, become again ennobled.

III

THE NEXT NECESSARY STEP

MAN MUST RECOGNISE the fact that he can win the ability to push up this great avenue of happiness and power only by the continued and consciously fostered growth of that intelligence and co-operation which have brought him to his present status. For it is obvious that his adjustment to the ever more complicated situations to which he may attain in his progress will require an intelligence ever higher, a co-operation ever more whole-souled, thoroughgoing, and better organised. Intelligence, in the form of technical knowledge and ability in respect to material things, has of late grown astonishingly; but, without a corresponding growth in social motivation and in the means of carrying it out, man's great new tools—so much more dangerous and more easily misdirected on a large scale than were the primitive instruments of the past—may work only misery and even destruction. *Love must balance knowledge,*[1] *or we fail.*

[1] Bertrand Russell, in *What I Believe* (Dutton, 1925), has designated " knowledge and love " as the essentials of the " good life." I

Hence, when we turn from contemplating our remarkable achievements and still more extraordinary possibilities, and proceed to weigh our measure of success so far in attaining those objects and conditions which (by the rules of our nature) we must regard as of primary importance to ourselves (i.e., the means of happiness), we must feel our earlier glow of satisfaction considerably abating. We have gone far, it is true, in combating fatal diseases, and we provide most of our number with food, clothing, and shelter somewhat more elaborate than in early times, and also with cheaper entertainment—of a sort. But on the whole the multiplication of the world's material wealth has as yet produced little or no essential betterment in the daily life and the spirit of most of the world's population. Their work is, if anything, even more monotonous and irksome than ever, their recreation is probably little (if any) more genuinely refreshing or inspiriting, and their returns fall much farther short of what they now conceive as desirable and physically attainable. The same is true of their family and social life and of their opportunity for social activity in general. The ideals that once served them as a

have adopted these terms from his book, using them practically interchangeably with the terms "intelligence and co-operation" employed in my lecture of 1925, from which the above text was derived with no essential changes.

source of solace and inspiration are becoming ever less acceptable as knowledge and disillusionment grow. It should indeed be possible, with modern knowledge, for the life of the people to be vastly improved in all these respects, were it not for the fact that the relations of man with man are not organised on a sufficiently co-operative basis, to permit a more social application of the fruits of civilisation. As things are, then, the consciousness of these possibilities—made tangible in the vastly increased and flagrantly abused comfort and power gained by the relatively few—does not serve as encouragement but, on the contrary, contributes greatly to the growth of the general discontent. The suicide rate—one imperfect barometer of unhappiness—has been leaping upward ever since the Industrial Revolution, till it is now from ten to twenty times higher than it was in the 18th century, and it continues to rise ever faster.

If all this represents what social evolution holds increasingly in store for us, then there is truly no reason why we should desire it or care to see the human species continue at all. The increase in its numbers, in its physical might, and in the period of its persistence, would not appeal to our ambitions. Mere strength and duration are not ends in themselves; if they were we should have to set up strange fetiches. For, of all the products of animate

nature, sharks' teeth and whales' ears most stubbornly defy the years ! Yet, compared with the continuance of human suffering, even these objects were better, even though they imply the savage struggle for existence on the part of the creatures that bear them. For these creatures, unlike ourselves, cannot in each moment realise the predominant misery of their whole existence. Better still, by comparison, would be either that fabled state called " Chaos " or the yet more fabulous " Primeval void."

It is not to be expected, however, that a form of social evolution containing so limited an element of co-operation as the present can really continue indefinitely amassing knowledge, external strength, and internal stability. It contains within itself, despite its mushroom growth, the seeds of its own destruction or its own transfiguration. For, unless men become organised in such a way that the incentives for service to the species as a whole can become predominant, they will continue to be subdivisible into self-seeking groups—nations, races, sects, social classes, and separate individuals—led in most cases by a few to whom such groupings happen to be materially advantageous. The cardinal fact of modern social organisation lies in the reduction of the mass of the population into a condition of dependence

upon a relatively few great private industrial enterprises. In the work of production in these enterprises, the workers must co-operate on a vast scale, but the direction of the work, and the distribution of products, is determined by the principle of maximum private profit of the small owning group. The immediate interests of this group in any one country stand in opposition to those of owners in other countries, and to those of the workers everywhere. So long as this principle of private profit in mass-production, this gambling with the lives of multitudes, remains at the root of society, its peace and prosperity cannot be indefinitely preserved by superficial measures —by parliaments, preachments, or police, by laws, by leagues, or by attempts at *laissez faire.* One " war to end war " will follow another, and one economic catastrophe another; each successive struggle and crisis will prepare the way for another still more destructive, as technique grows ever keener and passions grow more inflamed. If the continual smoulderings and the periodic explosions thus engendered do not, through their cumulative action, gradually disintegrate the structure of such a civilisation, one shock must finally come that is powerful enough to shatter its rigid bonds—enabling men in other groupings, and with other methods, to start building anew.

This would, of course, not be regrettable in such an age, since life without hope, without work that we believe in, without an abundance of love, is not worth the price of its preservation.

It is probable that, in such a society, the search for truth itself would eventually languish of its own internal debility. Although knowledge to-day is increasing more rapidly than ever before, we have seen how the repudiation of a social viewpoint, when combined with our present realisation of the littleness of individual man, leads gradually to a fundamental pessimism or cynicism with regard to mankind and the universe. This cynicism must look upon all knowledge, whether general or particular, and whether it promises to be relevant or irrelevant to the life of man, as equally good and equally bad. Thus it tends to dissipate the quest for truth into an infinitude of separated and devious channels, for the most part sterile, and devoid of human interest except as puzzles. Its findings, such as they are, will seek expression in a Latin of its own, which will serve not to make them universally understandable or to bind them with other knowledge into a living organic whole, but merely to lend a false distinction, based on reconditeness and isolation, to the pedantic professors thereof.

This trend is even now conspicuous in certain

branches of mathematics, philology, morphology, organic chemistry, geology, literary criticism, etc. —with all due respect to the very great contributions made in most of these subjects. It expresses itself not only in the choice of direction of research and in the manner of publication of its results, but frequently also in the denatured, dehumanised mode of teaching of even the most fundamental subjects, by those who are supposed to be specialists in them. This is one of the reasons why the teaching of these subjects in universities often arouses less real interest than in groups having slighter academic pretensions. It would not be impossible, then, for these very " founts of learning " to become stagnant and putrid, despite the abundance of " liquid currency " with which they might be supplied. As for technical industrial knowledge, there would of course be more direct incentive for keeping its flow clear and strong; yet its indefinite extension depends eventually upon the progress of the more fundamental researches. Hence its vitiation would finally follow that of the more general quest for truth.

Another way in which lack of a very highly developed social impulse must in the end lead to the downfall of any civilisation so afflicted lies in its biological undermining. For civilisation affords an excellent chance to breed for many sorts of the

weak, the stupid, and the vicious characters which are continually arising even among the " best " families. It might at first sight appear that this can lead to a situation little or not at all worse than that existing at present, so long as the sound and the superior also reproduce, mix with, and counterbalance the others; but this impression is erroneous and betrays insufficient understanding of the findings of modern genetics. The crux of the matter is that new mutations, though rare, are continually occurring, and cannot be prevented, and that, in any population whatever, the mutations which give rise to " defective " or " pathological " traits are relatively far more abundant than the " beneficial " mutations. We cannot, therefore, by any possibility escape the conclusion that the process of mutation will in time cause a gradual heaping up of undesirable traits of all sorts in any group of animals or plants, if individuals having the defective genes are allowed to multiply merely at the *same* rate as the others. One after another the remaining " normal " genes will themselves " go bad " through mutation, and then survive in their changed form. So long as this condition holds, then, a biological disorganisation will take place, and will necessarily continue without limit, or until the species disappears. Actually, there are indications that

under civilisation many traits that are detrimental to the species as a whole are propagated at a *faster* rate than the normal, so that the otherwise exceedingly slow biological degeneration is thereby hastened. This, when the increasing complexities of living are really calling for ever greater ability on the part of the group as a whole.[1]

In a state of nature, this problem of the accumulation of defective genes was often taken care of effectively by "natural selection": the strong man, the united tribe, more frequently won out, and the defective perished or failed to reproduce as abundantly. Natural selection of this primeval variety is to-day completely incompatible with happiness, sympathy, or civilisation

[1] No doctrine is more mistaken than that natural selection, considered as Huxley's universal truism, "the survival of the fittest," must of necessity always tend to result in a given species becoming better and better adapted for its own survival (barring changes in the environment). There are various special circumstances—and civilisation is the most notable instance—in which characters that give an individual "fitness"—in the sense of allowing him to multiply as much as or more than the others—are nevertheless deleterious to the species as a whole. Some such characters will spread through a population by the mere process of accumulation of mutations above described; others can multiply because, within that population, they do have a "survival value" or "reproductive value." Nevertheless such characters prevent the multiplication of more individuals of the species than they foster. In such cases, the natural selection that operates between competing species eventually makes itself felt by reducing or wiping out the entire species so affected, and thus the "undesirable" characters do tend to become eliminated in the long run. But this "long run" might occupy geological periods. Since this footnote was written a similar view has been expressed by J. B. S. Haldane in his *Causes of Evolution.*

itself. The only adequate alternative to it, however, is some kind of thoroughgoing eugenics. We use this term here not in its perverted modern sense—according to which it constitutes a biological weapon of the reaction—but in its only true sense: the conscious social direction of human biological evolution. But, as we shall see later, there is no chance that the mighty wheels of true eugenics could be set into motion, and then moved effectively in the really up-hill direction, except by a people thoroughly socially minded, one willing to sacrifice something of the present for a far-seen common ideal, one cognisant of the necessity (for attaining power and happiness) of organised and active intelligence and sympathy, working in close partnership. Failing this, a biological deterioration of the human race seems to be inevitable, and this might even endanger the dominance of man as a species.

So long as man retains the capacity to reap the advantages of tradition it is almost inconceivable that his dominion should ever be seriously threatened by any other species of animal (except perhaps a parasitic micro-organism), for he would be able to discover and check it long before its threat reached the danger point. But, since the inherent intelligence of civilised man is no greater than that of the man of the Stone Age, evidently

no very great decline in his mental ability would be required to carry it below the critical level necessary for retaining tradition in advantageous form. If, then, he does not cope, by conscious eugenic measures, with this problem of the regulation of his reproduction—inasmuch as it does not satisfactorily take care of itself in a state of civilisation—he must eventually be submerged into the primeval cauldron of competition with the 500,000 or more other animal species.

Here, then, we see the automatic check to which insufficient co-operation is subjected in nature. It is a kind of homeopathic remedy, and a costly one; but there is a wealth of life forms that is continually being replenished, and this wealth is lavishly expended in nature's game of life and death. What we call " progress " does come about eventually in a relatively few lines of organisms, and these may then bud forth anew to furnish more samples of species for trial. But as the process is essentially a blind one of trial and error, the great majority are doomed to spoilage. It is our concern to improve upon these natural methods, if we will. Individually, and as individualists, we cannot do that.

We see, then, that the happiness of the race, as well as its continued social evolution—indeed, even its biological maintenance—requires most

urgently a development of sympathy, a social idealism, a degree of co-operation higher than that which now exists. All this implies, primarily, a higher form of society. As in biological evolution, so too in social progress, one rapid change of a fundamental character generally demands another. The extension of knowledge, of civilisation, has brought new problems, as well as more stirring possibilities. Having once tasted of the latter, we cannot voluntarily relinquish them. The march of knowledge and technique must go on, and we must therefore match them with corresponding social adaptation. Not that we can ever attain a final system of conduct and of social relationships, which will hold good unmodified throughout the profound material and mental changes that are bound to occur in the future life of the species. But we must strive for new and more plastic forms of co-operation and codes of conduct, forms both fit to cope with the great tasks that will immediately confront them, and capable of changing again, and growing, with as little friction as possible, as our intelligence, our powers, and our self-set tasks develop. They must at the same time be forms that are psychologically healthy, both in an individual and in a social sense. That is, they must afford to the individuals participating

in them the greatest opportunity for satisfying the urgings of their own impulses, and in so doing they must guide this outflow of energy into such directions that a *maximum reciprocal reinforcement* of the activities and satisfactions of all will result.[1] The conscious recognition of the ideal of mutual help and endeavour, as opposed to the present principle of activity for purely private profit, must lie at the core of such a social organism.

Our present unhealthy social organisation is far from plastic, and until the mutative energy within it becomes considerable, little or no change in its fundamental structure can be effected. To take a biological analogy: in the cure of sleeping sickness, of syphilis, or of amœbiasis, a certain concentration of the drug is necessary for success, since the same amount of drug given in lesser concentration over a longer period of time will be counteracted by the parasitic organisms of the disease. In fact, the ability of these organisms to resist the drug becomes raised by practice and selection until a stage may even be reached where it is impossible to cure the disease without killing the patient. For these reasons rapid and energetic action is

[1] Thus, socially as well as individually, must ends tend to become means, and means ends—see p. 122.

essential for effectiveness, and although it probably will cause grave secondary disturbances in the system, of a temporary character, the choice lies between these and a continuance of the diseased condition. So too, in the body of society, the forces of social parasitism—the vested interests of reaction—are so strong, pervasive, and dominant that unfortunately they can be overcome only by an impetus of explosive yet directive violence, acting with sudden finality, to shift the equilibrium from the old basis to the new one.

Mere theoretical biology, psychology, or sociology, or any abstract body of learning, cannot itself accomplish any such general change in the organisation and attitude of man, so long as such change is forbidden by the self-interest of the class of men who have been put into power by the social system itself. However, the disharmonies of the present situation are calling forth in reaction to themselves more immediate and direct expressions of the regenerative forces of humanity —strong elemental tendencies operating within the body of society, primarily in the ranks of labour, organising and consolidating it. Through the mechanism of the class struggle, these processes are forcibly carrying us towards the radical economic readjustment needed, at which

point a degree of actual and conscious co-operation like that depicted above as a theoretical ideal becomes logical and acceptable. And after this fundamental change there will naturally ensue the widespread vitalisation of the intellectual theory of co-operation into an impelling power, as its pertinence to the new order is gradually realised. And thus at last, in place of medieval man's monstrous preoccupation with his individual life beyond the grave, the concept of the progression of our common life in this world will come to occupy a dominating place in all the ideals, hopes, endeavours, and institutions of the broad masses. Weaving itself into the intimate fabric of their daily doings, it will increasingly take concrete form until it eventually becomes, in its varied figures and expressions, the essential spiritual and physical substance of their lives. We talkers and writers cannot stop this process, but perhaps we can to some extent retard or hasten it and help to guide its direction. And so finally it will come to pass that the interests of the common man will tend to centre in the great enterprises of the human race, even as do those of some scientists to-day—in the conquests over matter, space, life, mind, and the other hitherto inscrutable riddles of existence.

Whereas the various enterprises of these kinds

to-day are the concern of but a few, it should be evident that their scope is such, and their ramifications and applications so extensive, that in some branch or other of the aggregate there will eventually be room for every man and woman to find some occupation. However small or subordinate his share, if it be but proportioned to the measure of his strength, he will find that, suffused with the spirit of the whole, it re-establishes in him an energising sense of pride and purpose that was lost when he stood alone, aghast at the seemingly indomitable magnitude of the universe. Man is a hunting animal, and he hunts in packs. In the pursuit of noble game the men of the Stone Age must have found their greatest inspiration; and we do still have Stone Age brains and must somehow "sublimate" these impulses to serve our present situation. It is when the spirit of the pack in chase is called into being—the zest of co-operative effort in pursuit of some great and countervailing object—that all of man's impulses merge into one harmonious blend of egotism, altruism, rivalry, love, workmanship, pugnacity, curiosity, awe, zeal, even ecstasy.

Whenever, in the past, conditions have led a people to be gripped by such a spirit, one of the great fervent mass movements of history has

resulted: the rise of Christianity, the Crusades, the enthusiastic union of medieval workers in building the great cathedrals, the conquests of Mohammedanism, the wars of liberation, and some patriotic uprisings—movements which, however mistaken they may have been in their objectives, always filled for the time being the psychological need of the participants. Under such conditions men can accomplish what would otherwise be impossible to them. Unfortunately, however, these movements have usually pitted man against man, to his own destruction, instead of leading man as one biological species against the hosts of nature. The latest abortive attempt to arouse such emotions—the World War—bears witness to the zeal with which the promise of a great, common endeavour seizes the soul of the average man, even when it imperils all his immediate personal interests.

Truly the mind of man is plastic as regards the aims to which it can attach itself, provided these can be construed as meeting the conditions of a common enterprise; and he has amply demonstrated the non-specific character of his hunting-in-pack tendencies—their power, as some express it, of " sublimation." On the other hand, whenever conditions are such that men drop apart into individuals, engaging only in the

petty and mutually injurious competitions of personal rivalry without a commonly conceded purpose, they become dissatisfied. Then they seek an outlet for their social tendencies by fixing their loyalties upon any smaller groups, conflicting with one another, in which they find themselves. Here, for the stirrings of the greater masses, there are substituted the cruder and more immediate appeals of football games, Holy Roller revivals, staged political elections, race rivalry, and the like. These conflicts are, to be sure, largely fostered artificially in the interests of the dominating economic group behind the scenes, but this is possible because such group strivings serve a human need that was inadequately taken care of otherwise. The broader, biological view of man will replace these with more satisfactory objects of joint effort.

As to the amount of human energy which can be diverted into these channels which do not provide the immediate means of subsistence, the World War proved objectively the tremendous surplus which even then existed. It is generally agreed by students of the subject that, with the progress of invention and of education and with the elimination of social wastage, the amount necessary for mere maintenance will dwindle into relative insignificance, and that, with appropriate

organisation, it will be possible eventually to relegate to an unimportant place the so-called "economic problem," in its narrower sense—i.e., the mere provision of food and protection to the then existing generation. So we see that, after all, the attainment of an optimal social organisation is not so much an end in itself as a means of making healthy the bodies and minds of individuals, of releasing their energies, and of allowing them to work co-ordinately in the higher struggles of the species as a whole, in its contest with outer and inner nature. The realm of such endeavours is unlimited and alluring. Here lies the real work of the generations yet unborn.

IV

WE AND THE WORLD IN CONTEST

DARE WE, from our present barbarism, attempt to prevision the great undertakings or even the routine practices of future civilisation? All we can do is to try to proceed a little farther along the threads of discovery in the general directions familiar to us even to-day. Their actual routes, however, will be in the future, as they have been in the past, contorted, branched, as well as much conjoined, and they will become ever more so as the loom continues weaving.

Moreover, in the realm of inanimate things, and also in the biological, the work must proceed by two different yet interdependent methods—the analytic and the synthetic. We must try to probe further and further into the constitution and ways of working of nature as we find her; and we must also combine and recombine these elementary factors, as we pick them out, into new and artificial forms, to help us not only in understanding but also in extending our common

life. Each of these two procedures is invaluable to the other: on the one hand, immediately useful inventions like the telephone, the telescope, the electric light, not only release energy for research but often directly make possible much farther-reaching analyses; and on the other hand, the deeper our analyses go the more do new worlds open up to us, delivering into our hands forces and materials which, combined into new inventions, produce results that previously would have been deemed miraculous. Thus did the theories of electromagnetism and the electron supply us with the basis necessary for inventing the radio and the radio-amplifier. The latter invention, in turn, has provided us with a sense organ for scientific investigation that may rival the microscope or the telescope. Pure science and applied science will thus go hand in hand. Only those scientists of the present day who are anti-social, and those so-called practical men who are purblind, can make invidious comparisons between these two forms of science.

So complicated and so extensive is this network of discovery and invention that it is impossible in a short space to set its main features in a logical arrangement. There is, for example, the chemist shaking his molecular kaleidoscope and tossing out a larger and larger number of novel, useful,

and instructive substances. Consider for a moment the radical changes in man's life which have already been brought about by the pre-scientific proto-chemical discoveries of former times—by the making of bronze, glass, alcohol, or gunpowder, to take just a few examples; and the changes in modern life caused by the chemical discoveries of the preparation of, for instance, Bessemer steel, concrete, salvarsan, or aluminium. And then consider the probable future effects of the artificial manufacture of food-stuffs—provided this proves really to be more economical than their natural synthesis through improved breeds of plants—and the effects of the production of a thousand and one undreamed-of artificial substances that may, in their different ways, be as useful as natural substances like rubber, camphor, nicotine, wood, petroleum, and asphalt. It is mere chance that these natural substances happen to have value for us. What, then, cannot the chemist make for us by more and more intelligent and preconceived design, when choosing from among the infinitely large number of compounds, mixtures, colloidal combinations, and still higher structural syntheses, that his theory will suggest to him as being possible?

But such substances, however complicated, are in a sense only raw material for use in further

combinations. The task of uniting parts into useful working arrangements, of inventing higher forms of mechanism employing both physical and chemical processes, is only in its infancy. As synthesis and analysis continue, and as new substances, processes, and sources of energy are found, the undertaking must produce forms far different from those of the present. The radio-amplifier and photo-electric cell are already beginning to give us some delicate sense organs for machinery, and other sense organs will follow. Through these and other means machines will be endowed with a far higher degree of self-regulation, adaptation to circumstances, and mutual adjustment to one another. On one hand, individual machines will become capable of greater plasticity in their modes of motion—more like living organisms and less "machine-like"; and on the other hand, through the establishment of further interconnections, machine-systems will tend to supersede many previously separate machines. Increasingly, too, the operation of machines will be made capable of control by a worker at any distance by the further development of sending and receiving mechanisms—automatic signalling systems, of which to-day's dial telephone is but a crude forerunner.

Now if the development of connections between machine and machine is important, still more important is the improvement of the relations between the machines and the men who run them and who profit by them. It is therefore to be expected that, particularly in the workers' society, special attention will be given to developing forms of machinery that not only are convenient to make, to run, and to repair, but also are physiologically and psychologically not unhealthful to work at—even, so far as possible, interesting and in their way beautiful. True, we have scarcely begun to think along such lines as yet, but in the past there was a cleavage between him who worked and him who enjoyed, and only the occupations of the privileged—such as hunting, judging, or dispensing grace—were made either comfortable or interesting. When the worker becomes also the ruler, this will necessarily be changed, and we shall hear no more of the fear that in the future the machine will rule the man, instead of the man the machine. The machine itself will be made to do most of the routine work, and to man will be left chiefly the task of solving problems connected with operations that cannot be standardised.

Now among the spheres of human work which have till recently undergone the least mechanisa-

tion there stands out most conspicuously that connected with the living-place. All its individually petty operations—its cumbersome bed-making, dish-washing, cleaning, mending, heating, etc., which, with cooking, to-day consume from one-fourth to one-third of the work-energy of mankind—can be almost completely mechanised and simplified into practical non-existence. Only social inertia and the fact that woman has been even more a slave than man have prevented us from being much further advanced in this direction than we are to-day. Food preparation must be centralised; if approached properly, this can be made to improve, not to impair, the quality and variety of our food. This does not, however, mean that people must be herded together to do their eating. Both clothing and housing must be rationalised. Space forbids us to enter upon the great possibilities in the latter domain. Suffice it only to say here that temperature regulation and ventilation will, in effect, bring us all to California when transportation does not. And, on the other hand, the improvement of transportation and communication will, as Wells pointed out long ago, make feasible the decentralisation of housing, and its better distribution over the surface of the land.

Meanwhile, each man, no matter where he is,

will be placed in potentially immediate communication with every other on this planet. As now he may communicate by mail, so then he will be able to communicate by voice and expression, being heard and seen—perhaps felt. Only a few years ago this would have seemed fantastic, but now most radio fans would recognise that it is coming. Will the false pretensions of a few be better or less able to dominate us then, when the organic connections of all with all have become so complete? And what will become of our universities then, our legislative halls, our theatres, and our other meeting places? Is it not evident that they will have become largely obsolete? Moreover, as a man may hear the sounds and voices and see the scenes and faces of contemporaneous events all over the world, so also will the methods be perfected for storing and reproducing conveniently and privately the noteworthy sounds and sights of the past. Thus will the means both of enlightenment and of entertainment attain maximum flexibility.

The cigar-makers' union nowadays employs readers to entertain and educate its members as they work. This idea may be carried much further. While the irreducible manual routine work of the future is being done—whether indoors or out—the workers will be able (wherever the work is of

such a character as not to require their primary attention) to listen to books, lectures, conversations, and concerts, delivered through space from sending libraries, any of whose stores can be tapped at will, or, alternatively, from records carried in the listeners' pockets. If the work permits, they will also look at beautiful, interesting, or entertaining scenes and events, and observe instructive demonstrations of processes. The individual microcinematograph, perhaps attachable to the eye, will do much to relegate unavoidable drudgery to the subconscious, where it belongs.

Though the human body crams much complicated machinery into a small space, we are scarcely beginning to make use yet of the possibilities in this direction for our artifacts. In days to come, much of our present apparatus for recording and reproducing sights and sounds and for manipulating symbols—e.g., books, libraries, phonographs, cinematographs, calculating machines, etc.—as well as our apparatus for yielding heat or motion in their various forms, will seem as unwieldy, cumbersome, and wasteful of human energy as an Egyptian obelisk with its hieroglyphics now appears when compared with a modern phonograph. In addition, micro-mechanisms will be much further elaborated for purposes of investigating, manipulating, controlling

and constructing ultra-fine objects. The world of the small must serve us as much as the world of the large.

If the alphabet and the printing-press have been such tools of progress in the past, it is hard to imagine the extensive effects of future devices like those above suggested for facilitating education and the transmission of thought in space and time. But not only will its transmission be so facilitated as almost to rival the pretensions of telepathy: the very process of thought will be aided and extended by new methods and devices for symbolisation, classification, analysis, and calculation. Speech was, in a sense, man's first invention in this direction; the so-called Arabic system of numerals and much of modern mathematics constituted others. Man's contributions will not lie only in the further development of these particular systems of formulation, or in such accessory mechanisms as adding and computing machines, slide rules, indexes, and card catalogues. Reference systems are even now being fashioned which will automatically make a collection of cards or annotations in any particular subject, feature, or combination of features chosen. More and more will not only symbols and formulas, but also moving pictures and moving models and various other forms of physical

representation and manipulation of facts, processes, and relationships—mechanical brains of increasing comprehensiveness and automaticity—usurp the functions of routine association, even as does now, in its very limited field, our multiplication table or its mechanical equivalent, the Chinese abacus.

Meanwhile the pure mathematician must continue his work of clarifying and reducing to simplest terms our methods of precise thought, and of seeking to express in one unified basic system the modes of relationship of quantities, categories, and diverse series of lawfully coordinated elements. In this fundamental language both the more elementary and the integrated facts of nature must be codified for further manipulation.

Now while the mechanical engineer, and even the chemist, comparatively speaking, are juggling with matter in its grosser forms, the analytical physicist, with his allies, the electrical engineer on the one side and the mathematician on the other, is coming to grips with naked energy and the more basic laws of change, stripped of their evolutionary elaborations and their consequent self-imposed intricate checks and balances. Superpower systems now exist, based on the discoveries already made along this line; but Steinmetz

thought that it might be practicable for a politically united world to have one continuous sheet of radiant energy, artificially generated, circulating over and over again about the entire earth, sent out by super-power radio stations, and capable of being tapped anywhere for an indefinite amount of power. There is now reason to conclude that this would not be feasible by means of wireless, but that it will be by means of improved material conductors. When this comes to pass, there will not be much carting of fuel to distant places, not much use of individual motors, nor combustion in them of gasoline, coal, or oil; rather there will be merely a reaching out and tapping of the adjacent power lines of the planetary circulatory system for their ever-available energy—energy reduced to its most convenient form, in which it represents the lowest common denominator of all kinds of work. Here indeed would be a " liquidation of our resources," and multitudinous forms of artifacts as yet undreamt of might develop when nourished by its protean impulse. Such artifacts, slaving for man and controlled from a distance, would release human energy itself for yet higher levels of accomplishment.

No matter in what specific form such developments become prevalent, the transmission and

direction of power are still in their early stages. The storage of power on a large scale, which is of equally great importance, has as yet hardly been begun at all. And intimately connected with the latter undertaking is the development of new sources of power. It is well known that our fossil chemical accumulations of energy in coal, peat, oil, lignite, etc., are but ephemeral, a transitory blaze even on the small time-scale of civilised man. And running water, though eminently convenient and practicable for the present, will give us a mere trickle of the energy we shall demand in the future. Nevertheless, practically inexhaustible physical sources of power surround us which are as yet undeveloped because of our present preoccupation with fossil combustibles and with water. These sources include the sunlight direct, wind, waves, rain, the tides, the subterranean heat, perhaps even earth motions, and—though most problematically of all—the forces in the interior of the atom nucleus. The conquest of these untouched and self-renewing supplies of power represents one of the most alluring fields of future endeavour.

With such new means of obtaining power, and with better apparatus for storing and using it, the work of our machines will increasingly progress from their present rather opportunistic occupations

to deal with more deeply laid and systematic projects, of much vaster character, and having far more significance in space and time. Instead of lumbering here, growing cotton there, and somewhere else leaving forest, desert, or snowfield untouched but for an occasional mine scratch or thin line of traffic, great engineering operations will be undertaken, to change the face of the earth in such wise as best to suit it to its inhabitants. Deserts will be flooded and irrigated, jungles subjugated, rivers and ocean currents diverted and controlled, forests placed, climate (in critical places) modified, and the earth in general made far more habitable, healthful, beautiful and productive.[1] Even the surface of the sea—in area twice as great as that of the land—must in some form be made to yield to the service of man the vast energy it constantly receives and wastes, and its great potentialities of food. Nature in general must be reconstructed by us for ourselves, on an ever grander scale.

With improved power and machinery there must also come a further revolution in transportation. We are too familiar with the far-reaching effects of such progress in our own time

[1] Of great interest in this connection is the recent book of Ilyin (translated by Kinkead; Lippincott, 1935) setting forth in simple vivid style the work of this type already in progress and in project in the Soviet Union.

for this subject to require more comment here. But besides the further conquest of the virtually two-dimensional space of the earth's surface, which has been man's heritage and prison from time immemorial, there must come the extension of our efforts at space-sounding in other directions, through penetration of the upper air, through great co-operative submarine operations, and through projects for plumbing the earth's interior. Even these, however, seem but tame beside the problem that challenges all the daring of the race—the problem of extra-terrestrial projection. If in this we ultimately succeed—as, from our present knowledge, seems probable even within the present century—we shall enter upon totally new phases of living and adventure that may be left to your own imaginations to elaborate upon. And in these speculations bear in mind this vitally important consideration: that in many other worlds besides ours living matter must coexist, and that in the star-bespattered abysses of the cosmos there must surely dwell a myriad exotic forms of sapient beings, more or less analogous, and yet more or less incommensurable, with ourselves. How much we may some day be able to learn of this life, through super-telescopes and other scientific telesenses, without coming into more direct contact with it, is at present

an unanswerable question; but any knowledge of it—not to speak of contact with it, whether direct or indirect—would introduce an incalculable element into our reckonings of the future, charged with unlimited potentialities for progress as well as for danger.

The ease with which we shall be able to attack such problems, involving enormous distances, masses, and forces, will depend partly on whether our physicists succeed in unlocking the atom nucleus at will and economically. Although they can already alter atom nuclei, with much labour and on an infinitesimal scale, it is still too early to predict whether they will be able to do so in a manner practicable for our use. Yet, as Soddy first pointed out, the attempt deserves our concentrated efforts, for there lie in the hidden recesses of the atom latent founts of energy that are inconceivably great, beside which the energies from combustion and from other chemical as well as physical sources now known to us pale as the candle beside the sun. In a handful of mist we should have as much energy as was needed to provide us with our one-man-power for a lifetime; in a ton of rock or water—it would matter little which—we should have power to run the industries of a city. Give him enough concentrated

power, said Wilbur Wright, and he could fly on a shingle. Here he would have more than enough concentration of it for such a purpose.

Not only would individual flight in air without unwieldy mechanisms then become universal, but propulsion through vacant space by means of rocket action would become relatively simple. Man should then be free of the earth indeed, emancipated from the need of the sun's light and heat, independent of particular elements for fuel, food, or protection (since changing the atom involves transmuting the elements); in short he would be as nearly a spirit in potencies as is imaginable for a corporeal being. He would, in this, have found the Archimedean lever which might move the very worlds. To be sure, the utmost care would be required in the handling of such a tool, and it is therefore to be hoped that as much intelligence would be brought to bear in using it as in devising it—a condition that is far from being satisfied in our handling of the mechanisms of to-day.

The possibility must also be borne in mind that, even if the ordinary atom cannot be unlocked in this way, it might be possible to use this principle, not as a primary source of energy, but—by the prior expenditure of energy from other sources—as a means of putting a part of this energy into

unstable atoms, where it would exist in maximally concentrated form. But whether or not the physicists, in their deepening quest, come upon any trigger in the atom that man's fumbling fingers may find and pull, they are bound to make discoveries which will affect fundamentally our ideas and our powers. Analyses, even now beginning, of the principles governing the groupings of the components of the atom nucleus, of the mechanism of emission of energy quanta, of the finer structure of electromagnetic phenomena, and of the potentialities of structure in what used to be regarded as vacant space, are revealing a realm of radical possibilities for further investigation and utilisation not guessed at two or three decades ago. Astronomical researches are co-ordinating with those of the physicists by showing that under the conditions of tremendous stress—heat, light-pressure, and " mechanical " compression—that exist in the interior of the various kinds of stars, the finer mechanisms studied by the physicist work out in unexpected ways. For not only do the atoms there become transmuted, so that their intra-atomic energy is released (and doubtless in other cases stored) as we should like to release it, but, according to some modern astronomers, in the black stars the very electrons of which the atoms are composed

may mutate bodily into quanta of radiant energy. And we are even now in our laboratories beginning to reproduce imperfectly and on a minute scale some of the conditions occurring within the stars.

Astronomy also hints to us not only that the energy of worlds may become scattered, as was formerly thought, but that there are places and occasions where it *may* gather together. If so, the second law of thermodynamics, with its pessimistic dictum that all energy must finally be dissipated until the universe attains a dead level of stillness, fails to have universal application. And so it may be that we shall yet find that phantasy of physics called " Maxwell's demon," which can re-collect for us in usable form the dissipated entropy of the cosmos.

This brings us up against remoter questions still. What are the greater forces of this cosmos—the agents clustering and driving apart the stars in their gigantic pinwheel universes or galaxies ? What determines the motions of these galaxies ? What is the shape of our physical space, and what are the larger characteristics of the integrated system of things ? Are they dependent very simply and directly upon the laws of the elementary particles and of the space itself ? Just how far will our road through the microcosm lead us to paths

of conquest in the macrocosm? That will be for us to discover and determine.

In all forecasting for the distant future our imagination must be grossly limited. Many of the possibilities which I have referred to in the domains of power and of communication would have been unthinkable only a few decades ago, when intra-atomic energy and radio-amplifiers were unknown; and similarly—as progress is speeded up faster and faster—a few more decades may bring much wider vistas into sight than we can now foresee. What then may not a few more centuries bring forth—a thousand years, a hundred thousand? Yet even a hundred thousand years is but a small fraction of the average geological period, or of the time elapsed since our ancestors parted from the ancestors of the species next of kin to us among all living creatures.

There is at present no need for pessimism in the face of these uncertainties. Even if, on the one hand, the unfolding immensities of space, energy, and subdivision seem further and further to belittle us, we may bear in mind that we too contain, *within* each one of us, a veritable universe. There are two billion seconds of thought to a life, and hundreds of trillions of cells to a body, each cell in turn containing trillions of finer particles. And these occur, not as a chaotic mass,

but bound in organisation almost inconceivably elaborate. In fact, it is almost certainly not too much to say that the amount of differentiation, and elaboration of parts and organisation, within the confines of a single human body exceeds that existing in the entire inanimate universe, taking into consideration at once all the systems of stars and galaxies visible to the most powerful telescope, together with their various divisions and subdivisions of structure as far as the very electrons. To set against the great world as a whole we have then in mankind a community of still more intricate worlds, inordinately smaller, but so highly organised that with their prevision they may be able so precisely to direct the minute forces at their command as to affect the monstrous masses of nature at the critical points, steer them against each other, and hold the balance of power.

It is impossible at present to set limits on the directive capacity of man made possible by his complex organisation, to say how far he may extend his dominion over larger and cruder objects than himself. Even in primitive times a puny man, with a well-placed dart, might blind and then dispatch a huge rhinoceros, or, by means of cunning lures, might lead a ponderous mammoth into a pitfall. And so at the present time

can a man, armed with the relatively undeveloped modern technique of the electrician and the chemist, arrange his petty materials in such a manner that, at the mere touch of a thumb on a wall-button, there ensues an explosion that wrecks an enormous cliff, or unleashes the pent-up waters of a mighty river. Each newly conquered object, in its turn, may moreover become converted into a tool, wherewith to attack a still greater opponent. And so our realm continues to expand, as yet indefinitely, as wit foils weight and skill enshackles strength.

V

THE INNER WORLD

THE FACT that we ourselves involve within us a veritable cosmos is in another way, however, a cause for concern. It means that in addition to the outer world we have an inner world to understand and to administer, a world no less intricate, and no less directly important to us all. And we cannot be considered as succeeding in our collective life struggle unless this inner nature, as well as outer nature, is subject to our intelligent control. Truly it was said: "He that conquereth himself is greater than he that conquereth a city." And again: "For what is a man profited, if he shall gain the whole world, and lose his own soul?"

For what, after all, constitutes success in the life struggle? The possession of great power is, for us, "necessary but not sufficient." Through all our visionings of progress we must again and again remind ourselves that the object of all these human efforts must be to increase the sum total

of the happiness of humanity. Only with this aim can we all pull together in such wise as to attain the fullest measure of our individual happiness. And the happiness of men clearly depends not only upon their temporary ability to control outer circumstances, but also upon themselves, upon their own inherent make-up. A long view will show that their ultimate power also, and so in another way their happiness, is similarly dependent upon both the inner and the outer conditions.

It is true, on the one hand, that a man cannot ordinarily live and be happy unless he has food, warmth, love, a modicum of comfort, and the opportunity to do his share of the common work. Hence a very considerable degree of control over the circumstances, both material and social, outside of and affecting the individual man, is obviously required. But, on the other hand, the most favourable outer circumstances imaginable would not be enough for a man who had a hæmorrhage on the brain, or hereditary insanity, or even a chronic neuritis, or for a man who was just a " natural-born crank." Many of us are this last—more or less; but we have all come in contact with at least one or two sanguine and energetic persons who push through life, despite obstacles and adversity, vigorous and even fairly happy, a

joy and a help to themselves and to others from childhood practically until death. I would far rather live in a world which was full of physical obstacles, but in which everyone, including myself, was of that kind, than live in a world which possessed intra-atomic power but in which all the inhabitants were of the opposite type. Biology concerns itself with the inner conditions. It is the duty of biology (including medicine) to make us all healthy, vigorous, and happy in " natural " temperament. But the duty of biology only begins there, as you will see: its further duty is to study, to understand, and to reach into the heart of the organic world and re-fashion this radically to man's own advantage.

Of course the most obvious of our immediate biological needs is perfect health. The pursuit of this in some directions, notably those having to do with fatal contagious diseases and with nutrition, is now well on its way. But health, as it is understood by the ordinary medical man, is not enough. All the little weaknesses, the indispositions, the neglected ailments, and the chronic or periodic inefficiencies of humanity—which perhaps even more than downright sickness work to our discouragement and detriment to-day—must gradually have their causes worked out, and, wherever possible, their appropriate remedies.

The modern physician usually has little sympathy for the "ambulatory" type of patient. Moreover, the causes of senility, and the way to postpone and alleviate it, are as yet remote from our ken, despite the claims of the "rejuvenation" enthusiasts.

[1]In addition to the minor and major afflictions to which men in general are subject, there are a vast number of inherited or partly inherited weaknesses that vary greatly from family to family. Many of these are individually rare, but there are, all told, so many hundreds or thousands of different varieties of them that it is a very rare family in which several such idiosyncrasies are not present simultaneously. Modern genetics shows that in many cases such ailments, occurring in different families, may be so alike in symptoms as to be indistinguishable from one another, yet have a fundamentally different hereditary cause; and each causally different innate weakness may present its own special problem of treatment. It will be seen that such a problem, concerned with a specified hereditary abnormality, cannot be attacked with the greatest efficiency by the medical man before the ailment has been classified in relation to what the individual's heredity contained. The recent introduction of this genetic

[1] The two paragraphs following were added in 1931.

point of view in pathology, neurology, etc., which we owe largely to Dr. Levit in Russia and to Dr. Vogt in Germany, vastly increases the work to be done in these subjects, and the need in them for a thorough understanding of genetics. While for some of these inherited defects a remedy would probably be difficult or impossible to find, there is no doubt that others could be alleviated or even cured, were a special series of researches carried out for each of the individual hereditary defects; although of course descendants of any treated individual would tend to inherit his defect just the same, and would have to be treated anew in each generation.

Even if, however, we eventually learned to "cure" all these ailments in this way, it would not be desirable to allow them all to continue to multiply from generation to generation, for then eventually all men would be burdened with all of them—though really there is no "all," since still newer ones would keep arising, till the whole inner fabric was destroyed. We should thus have to remould every bit of would-be-human protoplasm so radically as virtually to manufacture an artificial man from the ground up. This is a *reductio ad absurdum*, for the present millennium at least. To illustrate its absurdity we need only say that it would be far easier to take a healthy

ape and make a man of him—though of course no one in his senses would seriously propose anything of the sort. Meanwhile, however, as for the less direly afflicted human material which we now have, it must be our aim to patch it up as best we can.

Leaving aside, for the time being, the question of rare hereditary defects requiring unique treatments, there still remains a tremendous field for work in the investigation of the normal mechanisms of the adult human or animal organism. Even to-day the increase of our knowledge in this direction is rapid. For example, the isolation of specific glandular extractives like insulin, thyroxin, and adrenalin, which play such definite rôles in life's economy, leads us to guess that by the aid of these, and also (perhaps much more) by means of invented substances, we may eventually be able not only to control health much more effectually but even to modify individual constitutions, temperaments, moods, and characters to a considerable extent. In the realm of sex, startling discoveries have already been made in this direction. Thus, it is found possible by the injection of specific hormones to induce sexual maturity in the female rat long before the natural time of puberty—practically at any age desired—and to bring it on again long

after its natural lapse. In birds it has been found possible, in particular instances, completely to reverse the sex by operation.

Important as are such bodily affairs, both directly and in their effect upon our mental states, it must not be forgotten that the brain itself is a vastly intricate mechanism, the intimate physiology of which is to-day practically unknown. It would be strange if advances in the study of its structure and workings (call it psychology or brain physiology, as you will) did not cause a succession of revolutions in our methods of controlling men's conscious states and behaviour, revolutions incomparably more important than the relatively crude effects obtained by regulating the composition of the blood through gland extracts or otherwise. With this inadequate reference I must dismiss consideration of the possibilities of the as yet unborn psychophysical science of our descendants. This work must go on until we know the brain as well objectively as by introspection, and can say in just what material events each of our conscious operations consists.

Now, if much can probably be done, in various ways, to influence the characteristics of the adult, it might appear that work on the plastic embryo would offer an even more hopeful field for

research. At present, the actual physico-chemical processes operating in the causation of the development of the embryo form an almost unopened book. If we could better understand those processes we might be able to reach in at certain points and set up desired changes in the final form and functioning. For when we find that in the laboratory a frog can be made to develop without a father, that a starfish can be formed from a sperm in egg protoplasm without any hereditary contribution from the mother, that one sea-urchin larva can be made to grow from two eggs combined, or two or four from one egg; when we find further that in some species of animals such processes occur even in a state of nature, then we begin to wonder whether these operations of development will not in time prove to be far more adjustable to our will, in man himself, than has hitherto been imagined. And if even an ant can, and does, by artificial treatment of its embryos, determine whether queen or soldier or worker shall develop from a given egg, then may not perhaps *Homo sapiens* also attain the power to fashion all would-be queens and soldiers into workers? Now while in man (unlike ants) the particular distinctions just named are dependent upon the mental associations of post-natal life, rather than upon

chemical effects on the embryo, nevertheless there is already evidence that some deeper-lying deviations of human development, such as "Mongolian idiocy," which are recalcitrant to training, are affected by influences acting upon the embryo from outside of it, and should hence be susceptible to embryonic treatment.

As is now well known, J. B. S. Haldane has gone so far as to predict that in the not far distant future man may be reduced—or elevated—to "ectogenesis," wherein the embryo is artificially reared outside the mother's body from the start. Such an advance in the science of reproduction would be valuable in affording us a much more direct control over the development of the embryo; but, as we shall see later, it would be even more valuable in enabling us to rear selectively—or even to multiply—those embryos which have received a superior heredity.

Another alluring field of research is that of the fundamental nature of protoplasm and its constituents, and of their mode of physical and chemical action within the cell. In a sense, this understanding is the ultimate goal of biological analysis, and the findings made along this path are bound to be far-reaching also in the control they give us over vital activities. Jacques Loeb believed that the final aim of biology is the

artificial production of living matter, arrived at through such studies; though if he meant anything like the cellular forms of life that actually exist, then of all anticipations this I believe to be by far the most fantastic, on account of the stupendous intricacy of the structures involved. It would be folly to deny this as an ultimate possibility; but as yet we have no knowledge of the chemical nature of the genes, or hereditary particles, which are the most fundamental known units of living things, and of which there are a vast number of different kinds in every cell. Progress in some directions which may lead towards such knowledge is, however, being made, though it is necessarily very slow at present; and even if we do not soon learn more about the chemical nature of genes, at least we are attaining some practical knowledge regarding their changes, called "mutations," which we know are the building blocks of evolution.

This introduces us to what is by far the most portentous field of biological endeavour; gene knowledge and control—genetics. This vigorous science, now in its thirty-fifth year of postnatal life, bids fair to lead to the acquisition by society of incomparably more means of subsistence than have been consumed by the geneticists (thanks to the practical work of a mere handful of them).

Organisms are found to be far more plastic in their hereditary basis than had been believed, and we may confidently look forward to a future in which—if synthetic chemistry shall not have displaced agriculture—the surface of the earth will be overlaid with luxuriant crops, at once easy to raise and to gather, resistant to natural enemies and climate, and readily useful in all their parts.

This work is a far vaster one than the layman ordinarily realises, for there are many thousands of wild species of plants whose varied potentialities must be tested, and many species both wild and cultivated already contain hundreds of varieties and thousands of individual differences. By means of laborious crossing methods, these diverse types may be combined and recombined within ever wider limits, and so a virtually endless succession of specialised hybrid forms may be produced, differentiated into local geographical races each having characteristics especially suited to its peculiar conditions of cultivation and to the needs of the district. When to the potentialities of hybridisation are added those that will appear as new hereditary types arising by mutation, the path of change and adaptation is seen to be indeed limitless. So, for example, where desirable, herbs could eventually be

converted into trees, and trees into herbs; and in time even quite new forms of plant life could be invented and evolved, exotic growths whose characters we have not yet imagined.

Now if the above is true of plants, it certainly holds for animals also. Though the possibilities here are doubtless economically less important, they will in the long run prove even more spectacular. This may be better realised when we consider that even the man of pre-scientific days succeeded, in the course of many generations, in fashioning the wolf and the jackal into such quite unrecognisable forms as the Great Dane, the Pekingese, the poodle, and the dachshund, and made similarly radical changes in various other beasts, birds, and even fish. If this was done in the past, what miracles of transfiguration should modern man not be able to accomplish with the aid of the science of genetics? It is true that the road is a long one. But in our genetics laboratories we have, by selective breeding and crossing of flies from one original ordinary type, obtained within one or two decades descendants which I would defy any layman to recognise as flies, and which would even make the most competent dipterologist scratch his head. And now, by the help of X-rays, we can attain the same results in the space of a few

weeks. Flies breed much more quickly than mammals, but in their propagation they follow the same fundamental principles of heredity and variation.

But when we have reached the stage where our plants and animals have thus been shaped to our desires and virtually cultivate themselves for us—what of us men ourselves? Can it be that we shall at last be entering the fabled fools' paradise, in which we shall have nothing to do but pluck our already roasted pigs from the vines where these are growing, while we ourselves slowly and comfortably slide back to the stage of monkeys? Seriously speaking, however, even the man of to-day, with all his books and machines, is still, in his biological nature, only the man of the Stone Age, with a thousand elements of disharmony to the ways of civilisation. And the utmost that embryological and physiological science can do is probably limited rather narrowly by his elaborate internal system of regulation and by the comparatively stable equilibrium of many of the reactions whereby the genes mould the organism. We must also remind ourselves again that (1) any such treatments applied to the body of the individual would have to be repeated in full in each succeeding generation; and (2) biology of this kind

can never halt nor adequately compensate the march of the deleterious mutations previously mentioned, which are gradually but surely accumulating in our germ plasm and which are no longer removed by natural selection. With all our vaunted progress, then, without some effective application of genetics, we should face an ultimately disastrous process of internal deterioration. Judging by the previous rate at which biological evolution has occurred, and some meagre data on the frequency of mutations, it would probably require some thousands of years to accomplish this biological débâcle.

When, on the other hand, we consider the logical consequences of the application of the science of genetics to man, we find the picture more than reversed; we see progress of a hitherto inconceivable kind opening out before us. Those who think of genetics applied to man as meaning merely the prevention of reproduction among the feeble-minded and the instilling of a desire to bear more children among the so-called "upper classes" are committing an error as gross and ludicrous as that of the child who thinks of the moon as a golden ball caught in a neighbouring tree.

As regards the eradication of feeble-mindedness, many of the so-called eugenists are labouring under a misconception, for (as Haldane has

pointed out) sterilisation of all the feeble-minded would by no means prevent the reappearance of this trait in the next generation. If, as is often assumed, there are now about 300,000 feeble-minded in the United States, who owe their feeble-mindedness to the same specific "recessive" gene, then eight generations of complete sterilisation of all the feeble-minded would be required to reduce their number to half—namely to 150,000; and twelve more, or twenty generations in all, would be necessary to reduce them to 75,000; the subsequent diminution would be correspondingly slower and slower. This is because (on the rather questionable hypothesis still adopted by most eugenists, that feeble-mindedness is quite "recessive") genes for feeble-mindedness exist not only in the 300,000 actually feeble-minded people, but also in over ten million apparently normal individuals of our present population. These persons carry the trait in a latent condition, owing to the fact that they inherited it from only one of their parents, and from their other parent inherited the "dominant" gene for normality; they can, however, transmit their gene for feeble-mindedness to their children, and when both members of a couple are "carriers" and transmit the gene to a child, that child will be feeble-minded.

Hence, unless the reproduction of these seeming " normals " is regulated, most of the genes for the defect will persist to the next generation. After a thousand years of sterilising of only the outright feeble-minded, there would still be about four million apparently normal people carrying the gene for feeble-mindedness in this latent (" heterozygous ") condition; by this time the outright feeble-minded persons would number about 35,000 (assuming the total population to be what it is to-day). If the hypothesis of the invariable " recessiveness " of feeble-mindedness is incorrect, the rate of improvement would be faster than that calculated above, but still rather slow, because there is no doubt that a large proportion of persons carrying a gene for this defect are themselves of normal mentality.

We have seen, however, that feeble-mindedness of the extreme type is but one of an indefinitely large number of defective characteristics of greater or lesser magnitude prevalent in the race of to-day. Moreover, of all extremely defective individuals the feeble-minded are perhaps the most fortunate, inasmuch as they alone can never realise in any way what they are missing in life, nor note their cumulative failure. Probably, too, they are less of a burden on the rest of the population, since it is as humane to herd

them economically into institutions as to keep them in the home, whereas other genetically ailing mortals must commonly bring misery not only to themselves but to a number of those around them. All this should be taken not as an argument for a *laissez-faire* attitude regarding the feeble-minded, but as showing that the genetic problem concerns much more than these particular people.

Important in this connection is the fact that a large proportion of the hereditary defects are probably inheritable in some concealed form; that is, they can be carried, unsuspected, by normal individuals, and these normal carriers, in the case of many of these traits, greatly outnumber the visibly afflicted. Their adequate eradication within a reasonable time would hence require the elaborate investigation of all individuals of the population with respect to the possibility of their being " carriers," and the interference with the reproduction of a large proportion of them. As yet little or no attempt has been made to find ways of detecting " carriers " of specific genes, and we do not even know whether it will be possible, although methods based on the technique of immunology have long seemed to the author to offer a promising line of attack on this all-important problem of

exact genetic diagnosis.[1] But if we could detect all the "carriers," it is not unlikely that we should find the majority of seemingly "normal" persons to be "carriers" of some gross defect or other, or of several at once. It would then be obviously impracticable to advise that all "carriers" refrain from reproduction, and we should have to consider the whole problem, weighing one defect against another, and also taking especially desirable traits into account as compensatory factors.

As soon as we undertake the rating of different traits according to their relative merits or demerits, we are brought face to face with the fact that, after all, which characters shall be considered defective, which normal, and which superior, depends upon our point of view. From the standpoint of an unusually dull though not positively "feeble-minded" man, the brain of even an unusually clever ape is grossly defective, while from the standpoint of the ape the dullard is highly superior. From the standpoint of the average man, on the other hand, the dullard is

[1] Some preliminary studies of this kind recently made at my suggestion at the Medico-genetical Institute of Moscow by Levit and his co-workers, using human subjects, have already given apparently positive results, but much work will have to be done before we can be sure how generally applicable and reliable immunological methods may be in genetic diagnosis. Apparently positive results have also been obtained recently on flies, in independent work carried out by Gershenson at the Institute of Genetics, Moscow.

defective, while from the latter's standpoint, the average man is virtually a genius. Again, if our intelligence tests were to be relied upon (which they are not !), we should have to conclude that, in comparison with the brain of the judge, or of the army captain, or the professor, or the doctor, the brain of the average American—its development practically halted at fourteen years—is sadly wanting; yet the conclusion would be erroneous. In truth, the results from the intelligence tests have been shown to be modified very strongly by differences in training and general environment, in which the " overprivileged " classes have the advantage; so that we cannot consider the above comparison as evidence that persons in these classes have any inborn superiority of " grey matter." Nevertheless, the results of studies in which differences of environmental origin have been largely allowed for (as in the comparisons of foster children with natural children made by Burks) show clearly that very great hereditary differences in mental ability are really quite prevalent, though there is sound reason to believe that these differences have not been stratified into the various social classes as pictured by some " eugenists." There are children, then, who in comparison with the average child appear exceptionally gifted in

mentality, and still more remarkably brilliant children occasionally occur, sound also in body and in temperament, who even beside these gifted children are most extraordinary.

Where then shall we set our goal? A popular writer who is an ardent advocate of the old Puritan stock has suggested "sanity," vigour, and health as the fitting and "perfectly safe" ideals; but not all of us are Puritans, or even Anglo-Saxons, and we may doubt the ultimate safety and sanity of the "safe and sane." Fortunately, nature does not limit us to a particular fixed standard of sanity; her own standard has been ever changing, and she allows us always to make for the horizon. With this outlook, emphasis becomes shifted from the limitation of "defective" characteristics to the expansion and continued development of the characteristics that are especially admirable. All of us thus become subject to genetic scrutiny, and, as we found, even when considering the mere elimination of specified defects, the reproduction of the population in general must be affected thereby, if our findings are to be allowed to influence our practices in any rational manner.

VI

HEREDITY AND CHARACTER

THIS LEADS us to a consideration of the question: what are the means of judging what a man's genetic character really is? And what rôle has this genetic basis played in the making of the man as we find him? Even in regard to his physical traits, intricate studies may be required, and in regard to his mental characteristics (on the whole far more important) the difficulty is usually much greater. It might be claimed by eugenists that life itself affords a test of his innate mentality, and certainly, in order to gain light on his many-sided character, we cannot neglect to take into account his life story and achievements. Yet, as has been seen, even the response of an individual to a carefully worked out "intelligence test" is greatly affected by the environmental influences to which he has previously been subjected. Still more dependent upon the nature of his experiences and opportunities are his attainments and accomplishments in real life. The more unequal

the opportunities and the conditions of living are, in the society of which he is a member, the more largely will his success or failure, his knowledge or ignorance, his mental activity or inactivity, as compared with other men's, be determined by these circumstances of his social and material environment. Hence in our present society, with its gross inequalities, it would be obviously unfair to measure his original genetic aptitudes by his finally formed faculties or his *de facto* achievements.

Although it is safe to assume that even to-day, for the accomplishment of work that is really "great," an unusually superior combination of genes is *inter alia* necessary (particularly in cases where the individual has not been favoured by environment, but even in cases where he has been), nevertheless it is unquestionable that, if all the world's population had been raised and maintained in the manner most conducive to the favourable development of their capacities, a great number of persons who to-day have never emerged from oblivion at all would have risen to levels of thought and action as high as or higher than those attained by the greatest celebrities. Thus the impending social changes, whereby in a co-operative society the inequalities due to artificial class distinctions, race prejudices,

inherited fortunes and privileges are done away with, will bring us much closer to the ideal eugenic condition, in which practically every individual will have as favourable opportunities for development as every other, and will thus have his potentialities recognisable for what they are. Then, for the first time, we shall have a reasonably fair means of estimating a man's intelligence from a genetic standpoint.

If the above argument holds for the more purely intellectual qualities of the mind—general intelligence, special talents, etc.—it is even more pertinent of application to what might be called " moral qualities." These latter are usually highly complicated mental superstructures. While the original biological mainsprings of " moral actions " lie in emotional tendencies—such as affection, gregariousness, anger, fear, etc., the genetic basis for which must be variable in great detail of quality and quantity—nevertheless these emotions have become complexly organised and directed. This organisation has resulted to some extent from overt thought processes but usually much more from other forms of association (" conditionings ") impressed upon the individual by his past experience. And these thoughts and conditionings of the individual himself were in very large measure transmitted to him by others,

and represented the thoughts and conditionings of larger and smaller groups, based upon group experience. Thus the mode of expression of an individual's emotions is highly dependent upon " environmental " influences, including especially those of a social character.

So it happens that the major part of the cause of modern " crime " certainly lies in the nature of our social system, which tends to train large sections of the population in criminality and to give them both the economic incentive and the viewpoint appropriate for its perpetration. Moreover, the very same sort of ethics which, when acted upon in a crude and direct way and on a petty scale, brings its disreputable agent ten years in jail, will, when acted upon on a much grander scale and with the aid of abundant means and finesse, bring its respectable agent riches and honour, and even an artificial sort of greatness. It should be remembered, conversely, that in our society not only base motives but also those of the highest type may lead a man to jail. But even the " common criminal " of to-day for the most part has his own code of rightness, to which he may adhere strictly, and for whose limitations he himself should seldom be held responsible.

The radius of the circle to which a man's

sympathy actively extends, whether only to his pal, to his family or immediate circle, to his town or nation, to his fraternity, caste, creed or race, or to mankind or life in general, depends largely on the attitude of those who have reared and taught him, on the attitude of his associates and of the society in which he is embedded, and on the manner in which he has been treated by them. It is a notorious fact that the degree of provincialism of communities, and their hostile or friendly behaviour towards strangers, have varied from age to age, and from locality to locality, regardless of genetic similarities and cutting across genetic differences. And so, in general: moral standards, ideals, ethical customs, traditional sentiments, attitudes, and habits of conduct, which are so largely dependent on economic and social circumstances, vary greatly from community to community, from one social or occupational class to another, and even from family to family in accordance with the family's history and conditions of life; and in these various groups the acquired "norms" usually play a preponderant rôle in determining the individual's general course of action, despite genetic differences in the original intensities of various emotional and temperamental tendencies.

An individual brought up in a given social set—as, for instance, among professional people, or royalty, or skilled workers, or merchants (in fact, considerably narrower categories might be chosen)—finds in the vast majority of cases that he is able to fit in socially with this particular set of associates, and to conform with them sufficiently well to be acceptable both in intellectual and moral ways and in general *modus vivendi*. This is true even if, as a child, he was adopted into his present family from a totally different class. Yet "crime," in the sense of behaviour punished by imprisonment, is largely limited to certain social classes, and in others (as among college professors and their families) it practically never occurs. Certainly the latter groups are far from genetically pure. We see, then, that it is quite unjustifiable to condemn a man as genetically savage who has been brought up in a savage society or in a savage portion of society; and it is obvious that the first great step in the moral advancement of men must therefore be the moral reorganisation of the structure of society, whereby traditions, incentives, and means for leading a really moral life (that is, a socially useful one) are brought to all its members. Before that, our society must in every crime be presumed to have been not merely an

accessary but in fact the principal agent. And in the meantime we cannot hope, except in special cases, to gain much knowledge as to what rôle in determining any given individual's distinctive moral make-up, whether deficient or superior as compared with his fellow men, was played by genetic differences in intelligence and emotional trends, and what rôle by the differences in our highly unequal environment. Still less are we justified in appraising and comparing social classes as a whole with one another, in respect to possible genetic differences that might affect the " morality " of their behaviour.

As good a case could, if we wished, be made out for the genetic inferiority of the so-called " upper " classes as for their superiority. Whereas they have acquired traditions favouring greater " gentlemanliness " of manners and observance of legal forms (made by and for them), nevertheless it is also to be noted that there is not so much spirit of mutual self-sacrifice among them as is to be found lower on the ladder of prestige. Moreover, it may be inferred that a certain amount of selection has been continually occurring, tending to raise the less scrupulous, less humane, and more selfish individuals and families higher and higher in the ruthless financial battle and therefore in the social scale, and

pushing the more scrupulous, more humane, and less selfish farther and farther down. If this factor of selection were strong enough (we can at present scarcely gauge its strength in comparison with other selective factors), it would lead to the paradoxical result that, as between modern social classes, the outer signs and the inner strengths of the tendencies towards moral behaviour were inversely related to one another. If this should be true, then a higher rate of multiplication on the part of the "upper" classes—the condition so desired by most eugenists—would be eugenically most unfortunate, as tending to the establishment of a predatory in place of a constructive type. This reasoning, however, is probably almost as over-simplified and ill-founded as the more usual belief in the righteousness and genetic validity of the social stratification; and both alike neglect the preponderant rôle played, in our society, by the social environment in determining the differences in question.

But despite the present-day confusion of the environmental, and even of the social, with the genetic, and the attempt to set up false hereditary categories, there is certainly a genetic side also to the problem of human behaviour. That is, there can be no doubt that mankind must be

highly variable in regard to genes which determine the original physical basis of emotional and temperamental as well as more purely intellectual traits. For the brain is an extraordinarily complicated structure, both from an anatomical (including micro-anatomical) point of view and from a still minuter physico-chemical point of view, even before it begins to receive significant sense-impressions from the outside world. And this original structure determines the first capacities of the brain for emotional and intellectual reactions—determines, in fact, just what responses, inner and outer, it will give to any given stimuli, and how it *can* become modified by any given series of experiences. Now this original anatomical and physico-chemical structure of the brain must, like the structure of every other organ, depend in overwhelming measure upon the kind of genes that the embryo contained. In addition, many features of the brain structure developing subsequently to birth, such as the amount of its growth as a whole and innumerable finer details, depend upon gene effects that come into play during the later life of the individual. These later gene reactions must determine—to take just a few of the more obvious examples—the appearance of the walking instinct a considerable time after birth; the

appearance nearly simultaneously with the former (in a human child, a parrot, or a mocking-bird) of the instinct for imitating noises; the great intensification of the sex emotions at adolescence; the quietude that often creeps over the senile.

The brain, then, is far from being a simple blank page upon which the finger of experience writes as it chooses, as the more one-sided of the " behaviourists " of the Watsonian school claim. Many of the genes in question act *in situ*, directly affecting the structure and workings of the brain; others act by first affecting some other part of the body, such as the anterior pituitary gland, the sex gland, the walls of the arteries, sympathetic nerve centres, etc.; the latter parts in their turn, through altering the chemical content of the blood and by other means, secondarily influence the brain composition and functioning. Every psychological trait must be in some way dependent upon genes acting in both of these ways, some genes acting more and some less directly. Moreover, not only the mere presence or absence of the trait, and its time of appearance, but also its intensity and many details of its mode of expression must be influenced by the genes, just as we find to be true of physical characteristics of the blood, the

hair, the teeth, and all other parts of the body. In no way does this contradict the fact previously emphasised, that environment also is of the utmost importance in the development of the mental superstructure.

Now the genes here considered, which serve as a basis for the building of the brain structure, must be subject to internal changes—that is, mutations—in the course of generations, just as all other genes are, and so the individuals of any population must differ from one another in regard to the kind of genes for mental traits that they have inherited. Some of these mutations consist in drastic changes, in genes that have a large influence on the emotional or intellectual make-up; while others consist in unimportant changes, in genes that have a minor influence; and there must be all gradations between these two extreme degrees of effect.

We know the above principles to be true because they have been demonstrated to hold in the case of all organs and of all forms of life on which exact genetic studies have been made, and only the mystic would deny that the brain and its parts must be subject to the same general biological principles as are the other parts of the body. But we also have specific evidence of the existence of some of the more extreme hereditary

conditions referred to. Thus, ordinary feeble-mindedness and amaurotic idiocy are two examples of this kind involving intelligence—the first being present from birth, the latter gradually developing during childhood; while Huntington's chorea is an example of an extreme strictly hereditary neurological and (simultaneously) temperamental derangement, which, coming on gradually in the prime of life, becomes more and more exaggerated as age advances, so as later to transgress the limits of what is recognised as sanity and finally to result in death. Now exact genetic investigation shows that, where large hereditary differences in a certain trait occur occasionally in a population, smaller differences of a similar kind are much more common, but they are much harder to recognise as hereditary than the large ones because of the blurring effect of the variations due to environment which are present at the same time. In the case of certain physical traits, however, the abundance of the smaller hereditary differences can be directly proved by means of various specialised genetic methods, and in the case of human temperamental as well as intellectual traits we are provided with one such special method for the demonstration of the existence of small hereditary differences, in the comparison of twins.

Observations have agreed in showing the wide temperamental and intellectual differences that often exist between the two members of a pair of twins, similar to those which exist between two brothers, when these twins are of the kind known as " fraternal." In the case of " fraternal twins," the two members of the pair are known to come from separate eggs and sperm and so to have inherited different genes, just as any two brothers do. They are in fact related to each other just as two members of the same litter of dogs or other mammals are, and everyone who has dealt intensively with the rearing of young mammals (or even of birds) must have been struck with the great individual differences in disposition commonly occurring between litter-mates, almost from the time of birth, and despite a virtual identity in their experiences. Now, in contrast with these differing " fraternal twins," the so-called " identical twins " in man—which are derived from one and the same egg and sperm and hence have a quite identical heredity—are usually much more alike in these psychological respects as well as in appearance. This shows that the relatively slight environmental differences usually existing between litter-mates or twins are of rather minor importance, and we may accordingly conclude that no small part of the

pronounced and important differences which do so often exist between the temperaments of fraternal twins, and hence too of ordinary brothers or sisters in a family, are due to the different allotment of genes which they received from their parents. And if brothers are thus differentiated from one another by their heredity, unrelated persons in a population must, according to genetic reckoning, be thus differentiated to more than twice as great an extent.

In mammals other than man, the absence of any significant complications due to tradition makes it possible to demonstrate more clearly in another way the great genetic differences in emotional tendencies to which the brain is subject. Thus the differences in proclivities and in disposition between a carnivorous solitary animal, such as a tiger, and a herbivorous social animal, such as a sheep, are proverbial, and also the psychological differences between animals of two somewhat more nearly related species, such as a cat and a dog, a sheep and a goat, a cow and a zebu. But even within a single species the evidence is entirely clear. Thus, the differences in emotional bias between different breeds of dogs are unmistakable and well recognised, e.g., the nervousness, impulsiveness, and aggressiveness of the fox terriers, the persistence of the bull-dogs, the

steadiness and calm reliability of the St. Bernards, the inhibitions of the pointers. Although there are also important individual differences in temperament between the members of any one breed of dogs, these large differences between the averages of the different breeds are more clearly hereditary, since the same general characteristics reappear in a given breed in all parts of the world, despite diverse rearings and conditions of life and the practical absence of tradition. The warning must be stressed, however, that the alleged differences in temperament between different races of man do not furnish evidence for the same conclusion, owing to the importance of tradition in the formation of human attitudes and modes of behaviour, and to the fact that certain traditional modes of behaviour may, like genes, become widely dispersed over virtually an entire race, clinging to it through many vicissitudes of time and climate.

The real genetic differences between varieties of animals must have taken their origin in corresponding genetic variations of certain particular individuals, which had become selected by nature or the breeder in the given race until, by reason of the disproportionately high rate of multiplication of the descendants of such individuals, they had succeeded in quite displacing

the original type. Hence the existence of the above hereditary differences in temperament (as well as in various aspects of intelligence) between races of animals gives further evidence of the existence, within each race, of hereditary individual differences of just the same kind, even though the means might be lacking for ascertaining, in concrete cases of individual differences, what part of the effects found were caused by these hereditary factors, and what part by environmental ones. And if these hereditary individual differences exist in other animals, there can be no reason to doubt their existence in man also, despite the still greater difficulty of discrimination between hereditary and environmental effects in man, caused by the accumulation and extra-genetic transmission of tradition (including the whole social superstructure). In man, however, though these individual genetic differences must be at least as great as in animals, the racial genetic differences in the respects in question may well be insignificant in comparison with the individual ones, owing to the lack of any substantial difference in the manner of selection of most of these characters in the major part of the past history of various human races.

We see now that—to balance against our conclusion that the great majority of men, of any

class or section, could, if reared in any given alien caste or group, fit into it acceptably—we must set down a further principle: namely, that the men in any one such caste or group are themselves genetically very heterogeneous, in regard to genes that have important and diverse influences upon their emotional as well as intellectual characteristics. Some of these genetic combinations ("genotypes") must be far better, others far worse, suited than the average, for the conduct of life under the given material and social conditions. Just as different species of animals have a combination of emotional ("instinctive") traits that tend to make some of them highly social, and others of them asocial or antisocial, so too—though usually to a much less extent than different species—must different individual men differ genetically in traits of this kind, despite the fact that eventually they become trained to fit in more or less smoothly with the social scheme.

The importance of these genetic traits for social evolution is sometimes overlooked by persons who see in pure intelligence alone the distinguishing psychological feature of man that has led to his social evolution. It is pointed out that intelligent individuals will come to recognise that it is to their ultimate advantage to co-operate, and so customs

and training will become increasingly social. This is, of course, true in practice in any human group, but when it is stated in this simplified fashion the fact must be borne in mind that in an initially non-social group social behaviour on the part of any given individual implies an element of sacrifice, and this is not an advantage but a disadvantage to him personally. Unless provided with a social temperamental make-up, then, each individual would always have tried to figure out how best to outwit and otherwise outdo his fellows, even as he does to a lesser extent to-day. Thus it was not until, in the process of biological evolution, man's ancestors had developed a considerable genetic basis for social behaviour, that their group life could undergo development, and social evolution proceed. The way in which this genetic basis evolved will be considered later.

In the society of to-day, genetic differences of the kind in question remain important. We may admit that in present-day society, despite its still faulty organisation, things are so arranged that a considerable amount of social behaviour is personally advantageous, even for such individuals as would in the absence of tradition have shown the least tendency in this direction; and these aberrant individuals, if intelligent, will

learn to follow our outward customs in such matters. Nevertheless, they must lack a part of the normal motivation and emotional drive for social acts. There must often be occasions when selfish advantage runs strongly counter to the general good, particularly when society's back is, as it were, turned, and then especially will these individuals have a tendency to slip into socially less useful forms of behaviour than the normal individual of the same training would display.

On the other hand, individuals of the opposite type, characterised by more than the usual tendency to affection, kindliness, and fellow feeling, would be especially well adapted by nature to a co-operative form of society, and, given training and tradition like that of their fellows, they would derive more satisfaction than the latter from their co-operative work and would tend to carry out this work with more gusto and more truly in the spirit of the social scheme. They would thus tend to live more fully than the others in such a society, to suffer from fewer disharmonies and inhibitions, and (other things being equal) to achieve greater happiness and success both for themselves and for others. This would be because, for them, the means of living in a co-operative society—mutual aid—would at the

same time be an end in itself, to a greater extent than it would be for most persons.

In the above connection we may digress to point out what appears to us an ultimate principle of motivation and of voluntary activity in general: namely, that, as social evolution proceeds, as the form of society becomes higher, and as the individuals in it become better adapted to it, means and end will approach one another more and more closely, tending towards more nearly complete unity. Biological evolution, in so far as it proceeds effectively, has the same tendency. Complete unity, however, can never be arrived at so long as evolution continues, not only because of the indefinite complexity of adjustment and readjustment necessary, but also because of the continual arising of new means and new ends, as the possibilities of living change and expand.

The present genetic constitution of man of to-day being virtually the same as it was in the Stone Age, it would be strange if this genetic constitution had already become developed, on the average, in just the manner most perfectly conducive to life in a single vast co-operative society, even though, conversely, such a society would, all in all, be better adapted than any other to serve on a grand scale the ends even of

the present genetic constitution. There are certain genetic considerations which allow us to conclude that, in most species of animals, the process of biological evolution in respect to traits that make primarily for widespread mutual aid is a slower one than the evolution in respect to dexterity, intelligence, and other traits that help the individual and his immediate descendants as much as they do the group. For the former, the social traits, must in a state of nature become selected biologically mainly by means of inter-group competition, while the individually useful traits become selected both by inter-group and also by inter-individual competition.

Of these two processes, the inter-individual type is the more effective, first, because there are usually many more individuals than groups to select among, and second and more especially, because genetic variations—mutations—originally take place in but one individual at a time, and, if they are not then subjected to selection based on inter-individual competition, they can come to be represented to a significant extent in the group as a whole, as distinguished from other groups, only by means of a relatively rare series of accidents, whereby these particular genes happen by chance to become multiplied within the group. The larger and the fewer the groups,

the less effective becomes the inter-group selection, for both of the above reasons; yet, the further social life becomes developed, the larger and the fewer the groups must become. Hence the natural selection of genetic characteristics that are valuable only as a basis for social life tends to become automatically limited, to check itself, before it reaches fruition in a degree of development of the social qualities that would really be optimal for the species.

We must make an exception here of the ants, bees, and some other social insects, since in them the group as a whole, consisting of workers that are all the offspring of a single individual, shares the variations of that parent individual and virtually *is* that individual in an expanded condition, inter-group and inter-individual selection here being practically the same thing. In correspondence with this we find social instincts and behaviour and social characteristics in general developed to a far higher level among those insects than in man or any other social mammals or birds.[1]

In man to-day, on the contrary, the number of offspring per pair is more limited than in almost any other social animal (except perhaps

[1] R. A. Fisher also has called attention to these facts (in works published since the above was written).

the elephant), and at the same time the groups are very large. Hence in him we have the opposite extreme condition pertaining to the natural selection of social qualities; that is, in man the divergence between inter-group and inter-individual selection becomes widest, and the hindrances to the former and to the biological evolution of purely social traits are greatest. Inasmuch as the apes from which man started are not themselves such especially social animals, and since it has been only a few million years at most—in evolution a comparatively short time—since his divergence from them, it can hardly be expected that he should yet have reached an optimum degree of genetic development of the traits most conducive to social behaviour.

Those among us who are frank will readily admit the existence of grave shortcomings of this kind in our own natures. And along with an imperfectly developed basis for socially directed traits there often goes the possession of other tendencies that are actually anti-social—traits that must have been especially adapted to the intra-species struggle under primitive conditions, such as delight in the discomfiture of others, quick anger, blinding fear, strong jealousy, and self-deceiving egotism. These will be handicaps and will deserve at least a partial atrophy in a

future well-ordered society. No doubt a great improvement in these respects will follow from coming changes in the social structure, with their resulting effects on the material and social situations which to-day give more occasion for the expression of such impulses, and the concomitant reformation of moral standards, customs, "conditioning," and training will help incalculably. Nevertheless, the optimal functioning of any mechanism, nervous or other, requires, among other things, optimal materials—and in this case this requirement includes optimal genetic materials. How important these genetic materials are has been pointed out in the foregoing paragraphs.

There is room, then, for a genetic advance, not only in intelligence but also in the temperamental characteristics that make for co-operative behaviour. And after the adoption of an overtly social ideal by society as a whole, and the changes in economics, ethics, education, etc., that bring this about, the urge will become irresistible to utilise all means of progress towards this ideal that may be physically available. Thus it will come to pass that the desirability and the possibility of the genetic as well as the "environmental" improvement of mankind will then for the first time receive adequate recognition. Man,

in his state of greater enlightenment, power, and hope, will not wish to stop short of the best attainable, in genes as well as in other things; still less will he countenance the possibility of genetic degeneration.

VII

BIRTH AND REBIRTH

BUT HOW CAN the projected improvement in our hereditary constitution be brought about? Among the eugenists of to-day it is customary to assume that the reproduction of the "fit" can be sufficiently encouraged simply by giving young people a better chance to seek their partners for life and by inculcating in them high ideals of their duty toward the coming generation. How foolish to believe that many of the "best" can really be duped (as by *Führers* and *Duces*) into making living sacrifices of themselves, and into giving up most of what their own life has to offer, to make up for others who refuse to do their share! Under present conditions, when ninety-nine-hundredths or more of the direct burden of the children falls on the mother, such a view on the part of the masculine members of the community is indeed explicable. The view would not be popular with them if the shoe were on the other

foot. The intelligent woman, who can realise some of the opportunities that life may otherwise afford, will, it is to be hoped, always refuse to make of herself either a queen-bee or a galley-slave. If one of these two courses of life for women were always to be necessary for progress, then there could be no excuse for men's desiring progress, for themselves alone. It is true that some women, through special circumstances and favourable constitution, are even to-day in a position to bear and rear a family of the old-fashioned size, but for the majority, especially of the more idealistic and capable, who are struggling to emerge from their slave-psychology of yesterday, this is a form of martyrdom too protracted and repeated to be endured: one quick burning at the stake would be much easier. On the part of a host of intelligent women, therefore, there is a growing mass strike against child-bearing. May the strike prosper until the dire, age-old grievances have been removed !

Only by lightening the physiological, the psychological, the economic, and the social burdens on the mother now caused by child-bearing and child-rearing can we attain to a state in which real eugenics is feasible.

In the first place, there must be a completely legalised and universal dissemination of

knowledge about the means of birth control found to be most suitable from both the physical and the psychological standpoints. Effective education in this matter calls for free utilisation of the means of public enlightenment and propaganda, as well as active and unrestricted clinical instruction and aid. Abortion as a second line of defence must also be legalised and regulated, while at the same time its widespread exploitation by quacks must be suppressed. This is the first series of changes by which we can further the cause of voluntary as opposed to involuntary motherhood, partly relieve woman of the now oft intolerable burden of her sex, and help to convert child-bearing from a dreaded to a desired occurrence. Failing this reform, we cannot expect purposeful, " eugenic " reproduction, on the part of a minority of the population, to be able to compete successfully against the pressure of wholesale involuntary or only partly voluntary reproduction on the part of the majority.

In the second place, very little has been done (though very much can be done) to banish the unimaginable torture of childbirth—this because the doctors have been mostly men, who regard such pains in woman as obligatory, or even sadistically look upon them as desirable. Both the better application of knowledge already

existing, and also much further research, are needed here.

Thirdly, very little has been done, though very much can be, to make available the information and the means for doing away with the chronic illnesses which afflict so many children in their first six months of life, and which commonly wear down the already overstrained mother nearly to the breaking point, because " six-months colic " is considered a " normal " event—and why should doctors stoop to bother with any but " real " illness ?

Fourthly, very little has been done, though much can be done, to develop public utility organisations which will help in food-preparation, laundering, and other services necessary for infants and young children—work which commonly takes nearly all the mother's energy and time, but which could be accomplished in a much more expert fashion, and as economically as bread baking, thus releasing the mother for whatever work she is best fitted. This raises the question: to what extent will the child come to be reared outside of the home ? Precisely to such an extent as may make it possible for him to be provided with even more love, more health, and more enlightenment, with more motherly mothers, and hence with more brotherly brothers.

To what extent this will be, it remains for future society to determine experimentally.

Fifthly, we find that to-day even those mothers who through fortunate circumstances would have a portion of their time left over from the deadening treadmill of domestic routine can find no place for themselves in the present organisation of work, which demands all or nothing. And even those who could by special effort give all their time often find positions of the highest grade closed to mothers "on principle."

What an admirable eugenic system is all this, how accurately calculated to inspire women of the highest type of intelligence to enter upon the career of motherhood! In the face of such facts, how empty must the phrases and admonitions of the so-called "eugenists" ring upon the ears of the emergent female thinkers! Advise these to undertake motherhood when it is thus penalised—how singularly like the call from the old men for able-bodied volunteers for the World War!

The penalties must be removed; nay more, the very opposite policy must be embarked upon, so that instead of pushing the head of struggling woman still further beneath the swirling current, we actively raise and support it, and give her air, nourishment, and encouragement in her at best

none too agreeable task. Aim to re-adapt it to her so as to give her a dignified place, to amend our attitude towards pregnancy, to reorganise our medical outlook and practices—else it is folly and brutality to talk eugenics. Though the eugenic motive to-day cannot have the driving power to work such industrial, social, and medical changes, they are coming none the less, with the change in our industrial methods. These, even under our profit system, call more and more for the labour of women, take over more and more the functions of home industry, drive women out of the home by giving their husbands inadequate means of supporting the family, and, by thus giving woman greater economic independence, unwittingly bring her into a position where she has more desire and ability to make and enforce her own demands. And with the change from the profit system to socialisation, the emancipation of women will of course be greatly hastened, both directly and also as a response to the more rationally and actively developed industrialisation process.

These are the social forces which are inevitably working to bring women into a position where it will be possible for them to let remoter considerations influence their decisions concerning the

bearing of children. With the spread of birth-control technique, and of the opportunities for using it, with the easing of the burdens imposed by the bearing and rearing of children, with the downfall of the traditional ideas regarding woman's status, due to invention, industrialisation, and eventually socialisation, and with the downfall of dogmatic theology, due to the same factors as well as to theoretical science, there will necessarily be carried down much of the associated system of superstitions, taboos, and dicta regarding the family relationship and sex relationships in general. Thus the way will be opened for the direction of such matters by considerations of reason and love, in the true interests, on the one hand, of the future generation, and, on the other hand, of the participating parties, rather than in obedience to the commandments of a supposed supernatural dictator or to a mystical set of absolute ethical axioms.

At the same time the discoveries and inventions of advancing biology in the fields of reproduction and development must sooner or later give us radical powers of control over what has hitherto been the female's rôle in child-production, which will greatly extend both the possibilities of eugenics and our ability to order these processes in the interests of mother and child. The making

of such inventions will be favoured when we have a system in which their value will be duly appreciated.

Even to-day only a relatively slight advance in technique would be needed to enable us safely and without incision to transplant the mature or fertilised egg from one female into another, and have it develop. This has already been done in the rodent, but by operation, and no one has been sufficiently interested as yet to develop the technique further.[1] It is conceivable that the fertilised egg would develop properly even if placed in the uterus of some other species of animals, though it probably would not do so in any animals that can be readily domesticated, because of the unsuitable conformation of their placentas, not to speak of the chances that antagonism may develop between the embryonic and the maternal tissues in some of their chemical reactions. The possibilities of transplanting portions of ovaries from one person into others has also received inadequate attention. Here we encounter the difficulty—perhaps in most cases insuperable—of chemical antagonisms between one individual and another of the same species;

[1] As this goes to press, word comes that Carl Hartman has succeeded in a method for obtaining the fertilised egg in viable condition without operation in the monkey.

yet the operation has been successful a number of times in mice, guinea-pigs, and fowls, and fragments of the ovary in both donor and recipient individual afterwards tend to regain the size of the original whole.

Growth of small amounts of ovarian tissues outside the body can also be carried on, though as yet exactly the right conditions for the forming of mature eggs from the artificially cultivated tissue have not been attained, nor is research proceeding very actively in that direction. It has become known that, while within the body, certain specific substances, such as one from the anterior pituitary gland, are necessary for the ripening of the egg, while others—e.g., that from the corpus luteum gland—are inhibitory; and hence the road is open to further research along these lines, on extirpated ovarian tissue.[1] There is no doubt that, if mature eggs were thus obtained, they could be fertilised and implanted in the uterus of the same or any other functioning female, and that they would then develop. Whether or not human eggs could be caused to develop without fertilisation—without a father—it would at present be impossible

[1] Here we may record another recent success. In an article that has just appeared in *Science* (Vol. 81, p. 621) Alexis Carrel and Charles A. Lindbergh report that they have obtained growth in entire ovaries excised and kept alive outside the body by a special perfusion technique; they do not, however, report egg production as yet.

to predict, as no serious attempt has yet been made along this line, although the feat may easily be performed with some invertebrate animals, whose eggs are more convenient to obtain and to grow. Few biologists of our age seem to realise the social and eugenic significance of such work, and other persons are not aware of the biological potentialities.

All such accomplishments as the above would greatly extend the reproductive potencies of females possessing characters particularly excellent, without thereby necessarily interfering with their personal lives—or even, we may add, with their theologies, since the latter did not anticipate any such contingencies when they were framed and as yet contain no injunctions against them. In such ways, and by otherwise controlling the development, the twinning, the size, etc., of the embryo, and the duration and other conditions of pregnancy and labour, considerable changes may be wrought in our methods and customs concerned with the production of children—changes permitting a much greater degree of control over our choice of these children, even before we reach that ideal condition of complete ectogenesis, or development of the egg entirely outside the mother's body, pictured in Haldane's *Dædalus*.

Most of the preceding has been concerned with the conditions affecting our selection of maternal protoplasm in the production of the next generation. But the conditions affecting paternity are, for the child, vastly more important; not that the father contributes more than the mother to the child's characteristics—for he shares almost equally with her in the determination of its inheritance—but because, on account of the enormous number of reproductive cells which each male produces (many billions in all), it is biologically possible for the selection of male germs (sperm) to be incomparably more rigorous than that of female germs (eggs). Thus it would even now be possible by means already tried and proved—that is, by artificial insemination—to determine that a vast number of children of the future generation[1] should inherit the characteristics of some transcendently estimable man, without either of the parents concerned ever having come in contact with or even seen each other, or having been in any way disturbed in their separate personal and family lives—beyond the very important disturbance of the entrance of

[1] Fifty thousand is a reasonable estimate with the technical methods now at our command. With a modicum of additional research, means could probably be found for multiplying the efficiency of the insemination process several times more.

the child. Only social inertia and popular ignorance now hold us back from putting into effect (at least in a limited experimental way) such a severance of the function of reproduction from the personal love-life of the individual. This separation cannot be indefinitely postponed, because social inertia has its limits, and, when it comes, it must react to the emancipation and mutual advantage of both these all-important phases of life. To claim that we must wait for ectogenesis first is only to admit that we do not really have the courage of our convictions.

Personal love, on the one hand, which is largely a matter of imperative emotions, that do not readily wait for the approval of expedience and foresight—or, if they do, tend thereby to become thwarted, perverted, and cankerous—has in the past never been a willing and efficient slave to the needs of reproduction. Make considerations of reproduction dictate the expression of personal love, and you not infrequently destroy the individual at his spiritual core; thus "eugenic marriages" cannot as a whole be successful, so far as the parents are concerned. On the other hand, make personal love master over reproduction, under conditions of civilisation, and you degrade the germ plasm of the future generations. Compromise between these two policies, and you

cripple both spirit and germ. There is only one solution—unyoke the two, sunder the fetters that from time immemorial have made them so nearly inseparable, and let each go its own best way, fulfilling its already distinct function. The physical means for this emancipation are now known for the first time in history.

When we consider what the recognition of this principle would mean for the children—for those future men and women the character of whose lives we cannot in any event escape the responsibility of predetermining—our obligation becomes clear and compelling. The child on the average stands half-way, in its inherited constitution, between its father and the average of the general population, and so it would be theoretically possible even now—were it not for the shackles upon human wills in our society—so to order our reproduction that a considerable part of the very next generation might average, in its hereditary physical and mental constitution, half-way between the average of the present population and that of our greatest living men of mind, body, or " spirit " (as we choose). At the same time, it can be reckoned, the number of men and women of great, though not supreme, ability would thereby be increased several hundredfold. It is easy to show that in the course of a paltry century or two

(paltry, considering the advance in question) it would be possible for the majority of the population to become of the innate quality of such men as Lenin, Newton, Leonardo, Pasteur, Beethoven, Omar Khayyám, Pushkin, Sun Yat Sen, Marx (I purposely mention men of different fields and races), or even to possess their varied faculties combined.

We do not wish to imply that these men owed their greatness entirely to genetic causes, but certainly they must have stood exceptionally high genetically; and if, as now seems certain, we can in the future make the social and material environment favourable for the development of the latent powers of men in general, then, by securing for them the favourable genes at the same time, we should be able to raise virtually all mankind to or beyond levels heretofore attained only by the most remarkably gifted.

Do not imagine that the obligation is one that can be escaped. With such means at our command, the conscious withholding of these gifts from the people at large, by continuing our present completely *laissez-faire* methods, would in itself be a decision, a course of action—and an anti-social one—directed against the well-being of humanity. Mankind has a right to the

best genes attainable, as well as to the best environment, and eventually our children will blame us for our dereliction if we have deliberately failed to take the necessary steps for providing them with the best that was available, squandering their rightful heritage only to feed our heedless egotism.

But just in proportion to the importance of this far-reaching revolution in human biological affairs would be its danger if misused. Such a system—if it could somehow be put into full effect at once in our country to-day, and directed (as it eventually would be) by the same forces as direct our Press and general propaganda—would undoubtedly lead to a population to-morrow composed of a maximum number of Billy Sundays, Valentinos, John L. Sullivans, Huey Longs, even Al Capones (and I should like to name, besides, various prominent characters in our military, financial, and university circles!) Of course we must recognise that the development of these types has required our specific social environment, yet in so far as any genes may lay a favourable basis for such development in given individuals, these are the genes that would be most highly prized in our community, and our artificial selection would hence tend to work in these directions. It would be

disastrous, therefore, to attempt such reproductive methods on a grand scale so long as the present ideology of individualism, careerism, charlatanism, unscrupulous aggression, and shallow hypocrisy prevails.

Little fear need be entertained, however, that society in its present form will set itself to any such *coup de grâce*. In the first place, its present form is even now in process of disintegration. In the second place, a sufficiently deep-seated change in the attitude of the population in general in regard to reproduction can come about only after the unequivocal establishment of economic and social transformations which will bring more dignity and rationality, and less superstition, into the relations between the partners in love. These changes, by socialising our attitude in general, will socialise also our conception of our duty towards the coming generation. Moreover, an essential feature of the process of socialisation is its effect in spreading the knowledge and technique of science. The workers of the world are the only class with the economic incentive, the ethical background, and the force to accomplish this general transformation; and so when they come into their own it will be they, primarily, who will have the desire and the opportunity to reap the fruits of the victory in

genetic as in other respects. By that time the old standards, formed under the combined influence of the predatory principles of the leisure class and the partial slave psychology of the workers, will have been largely swept away.

Besides the influence of the generalised social changes noted above, it may well be that certain specific inventions will help to pave the way for new reproductive practices and will serve as an introduction to the later application of a more nearly complete rationality, volitionality, and social motivation in the creation of our offspring. So, for example, invention of the means for controlling sex, through the sifting out of the male- from the female-determining sperm—a difficult task, but one that may perhaps be mastered by an advance in our physical technique—would further such a change very radically.[1] And regardless of whether or not this

[1] The effect of this invention would be important in several ways. First, it would accustom us to accept the technique of artificial insemination. Secondly, it would force society to regulate artificially the relative numbers of the two sexes, and so to recognise its responsibility in reproductive matters, perhaps not until after the sex ratio and sex relations generally had first been upset by an unregulated use of the method—a result that would in itself have further repercussions in the direction of rational control. Thirdly, it would definitely make possible within two generations the abolition of all hereditary defects of the type known as "sex-linked," without at the same time imposing any restrictions on the number of offspring a person might have; and it

particular feat proves to be practicable, there is little doubt that there will be other important technical advances of one kind or another (some of which have been outlined above) which would be similarly conducive to the adoption of a new code of ethics governing in a more intelligent fashion our reproductive behaviour. In the formulation of this code, the new rôle of paternity, in offering a genetic leaven, could not fail to be recognised and utilised.

All the foregoing affords an illustration, applying to one particular realm of human activity, namely, reproduction, of the truth of a general thesis long ago set down by Karl Marx in the introduction to his *Critique of Political Economy.*

would thus focus attention on the problem of genetic improvement and strengthen the " eugenic " motive. Fourthly, the existence of the possibility of control over the sex of a " child of choice "—one derived from chosen sperm—would act as an inducement to having one, since it seems that most persons prefer daughters as adopted children, but sons as natural children. The tendency to such a division as between children of choice and children of love-matings would from a genetic point of view be beneficial, because of the greater degree of selection for parentage possible among males than among females, and the consequent greater desirability of raising the average quality of females rather than of males.

The present author and Altenburg, with these possibilities in mind, attempted in 1919 to work out the technique of such a sifting out of the two classes of sperm; but it soon became evident that the knowledge of sperm physiology of the time was as yet insufficient. Recently Koltzoff, of the Institute of Experimental Biology, Moscow, has obtained suggestive results along these lines, though it is as yet too early to appraise the efficacy of the electrical sifting method which he employed.

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According to this thesis, the development of new technical devices eventually results in the upsetting of the conditions of production, and so too eventually changes established institutions that were long regarded as necessary and in the nature of things. In this case the new technical devices in question consist in the technique of artificial insemination and in accessory biological inventions; and the production in question is in this case *re*production, which has hitherto been carried on within the limits of monogamous marriage. This does not mean that such marriage will now be destroyed as a means of life partnership and companionship, and as a centre for the upbringing of the children (including the "children of choice"); but it does mean that it will no longer be the sole approved biological means of procreating the generation to come. And no doubt it will in time undergo a further evolution.

It should be needless to point out that in the new society participation in the type of reproduction in question, designed for the sake of the children, will be entirely voluntary. It is to be anticipated that, with the realisation of the possibilities of such procedure and with the making available of the means of carrying it out, more and more individual mothers as well as

couples will become eager to participate in it. No doubt many of the participants will wish also to continue in the old method of reproduction—to some extent at least—but will wish to add to their natural family one or more "children of choice." Such a dual course would in some cases present psychological and social advantages and it would at the same time meet the genetic desiderata sufficiently well. The selection of genetic material will also be voluntary. We may trust the members of future society not only to have, in general, sound ideals in this matter, and a fair capacity of recognising merit within their own line of work, but also to be guided by the advice of combinations of publicists, geneticists, medical men, psychologists, and (above all) of critics from the fields especially involved—in short, by the best thought of the age. Compulsion need enter, if at all, only in a negative rôle, as a potential force standing ready only to prevent exploitation of the enhanced possibilities of multiplication by unduly egoistic, aggressive, or paranoid individuals.

The question may now be asked: what are the most important ideal characters, the genetic portion of whose bases we must strive to make as favourable as possible? It is these ideals which are the all-important consideration in the first

place since, as we have seen, eugenics in the wrong direction would present a far more abhorrent picture than no eugenics at all. What should these ideals be, and how are they to be made acceptable? The whole course of human prehistory and history makes the necessary ideals obvious and unmistakable; they are (aside from physical well-being) primarily two: highly developed social feeling—call it fraternal love, or sympathy, or comradeliness, as you prefer; and the highest possible intelligence—call it analytical ability, or depth of understanding, or "reason." Each of these two traits is of course the resultant of a complex system of more elementary factors, and the development of each is highly responsive to environmental influences, as well as affected by genes. Now these two traits, when active and well organised, issue in the "co-operation" and "knowledge" by which mankind has advanced, is advancing, and must advance for a long time yet to come. Other desirable traits, bodily and mental, may be regarded as simply accessory to the effectiveness of these (for instance, that series of special proclivities whereby we, unlike apes, can learn to speak); and many systems of such biological accessories are probably still to come in the distant future, even as in the distant past the lower animals

developed through natural selection many systems accessory to dexterous motion—such as special muscles, bones, circulation, nervous system, sense organs, etc.

The paramount position of these two ideal characters—comradeliness and intelligence—is not generally recognised to-day, but its recognition is bound to come with the coming changes in the structure of society which will put the latter on a more consciously co-operative basis. Then, but not before, will it be possible for people in general to awaken to the true ideals of humanity, and then only will they even *desire* such genes as would be of aid in working towards these ideals. Then will they see that positive advance in these directions is incomparably to be preferred to the attainment of a supposedly perfect mediocrity. Then too, and not before, will there be fair means of recognising most of the individuals in whom an exceptional concentration of such desirable genes lies, since before then the majority of these genes must be buried beneath the weight of economic and social oppression. Meanwhile—at present—a false premium is attached to gifts of the " upper " classes, gifts which may be connected with dangerous unrecognised failings. Associated, too, with these class prejudices and artificial class inequalities of

to-day there are equally unjust race prejudices and artificially created race inequalities. In regard to really important characteristics, the natural differences between the races pale into insignificance beside the natural differences between individuals—so much so that an impartial science of genetic improvement could not afford to take the former into account at all in its procedure. Thus we see that only the eugenics of the new society, freed of the traditions of caste, of slavery, and of colonialism, can be a thoroughgoing and a true eugenics.

The judgment of genetic merit, as distinguished from environmental good fortune (which can of course never be completely equalised), will become increasingly exact as time goes on, and it will be desirable, in this matter, to use methods as objective and as little susceptible to being influenced by the " personal equation " as possible. And although, as previously stated, achievement offers one of the most important criteria for the judgment of all-round worth—there being no doubt that in the great majority of cases very eminent individuals have capabilities considerably above the average, particularly in communities established on the principles of real equality of opportunity and thoroughgoing

co-operation—nevertheless it will have to be recognised that the amount of worldly acclaim given a man in his own generation furnishes by itself no sure or exact measure of his intrinsic greatness. This emphasises the need for the further development of objective criteria. Of course we cannot hope ever to obtain " perfect " measures, nor is anything approaching perfection of judgment really necessary for our purposes, since any degree of genetic betterment, in any trait, is advantageous to the next generation, and it will be a step in the right direction, provided our method does not systematically tend to produce at the same time a decline in other, more important particulars.

Although we need not fear the likelihood of the contingency just suggested, it would be very helpful, both for the meeting of such problems and also from more purely genetic considerations, if our biological technique could be advanced to the point of enabling us to make living laboratory cultures of the male reproductive tissues, in which the male germ cells could multiply and come to maturity. There is no reason to believe that this would necessarily be a very difficult matter. Cells of other organs can be cultivated outside the body, though certain special conditions, as yet unknown, must be

reproduced in order to enable the germ cells to mature. There has been little or no research as yet to determine what these conditions are. No doubt if these cultures could be made at all, they could be maintained for an indefinite period of time, long after the death of the individual from whom they had been taken, just as has been found feasible in cultures from the skin, heart, and other tissues; and so they could eventually supply an indefinitely large amount of material. If this could be done, it might be a salutary rule, eventually, not to make use of such material in any considerable way until say, twenty-five years after the death of the donor. After this length of time society would often be in a far better position to judge fairly of a man's achievements and his general worth, than during the heat and struggle, and the possible intrigue and bias, of his own personal life; there would also, by then, have been some opportunity to judge of his genes by observations on the character of a limited number of his progeny. How fortunate we should be had such a method been in existence in time to have enabled us to secure living cultures of some of our departed great ! How many women, in an enlightened community devoid of superstitious taboos and of sex slavery, would be eager and proud to bear and rear a child of

Lenin or of Darwin! Is it not obvious that restraint, rather than compulsion, would be called for?

Be the above as it may, it can readily be seen that the guidance of selection, and the establishment of the theoretical principles pertaining to it, will constitute a highly important work, calling for elaborate scientific study in varied directions, biological, psychological, sociological, philosophical; and a real science of eugenics —that is, of social eugenics—may then first be truly said to have been born. With all its associated ramifications it will constitute one of the culminating activities of human thought and endeavour, and one which will grow ever greater and more inclusive as it progresses. Much more could be said about the genetic technicalities concerned and the singular adaptability of this method of breeding (the intensive selection of sperm) to the eradication of defects by a process of gradual displacement; to the detection and sifting out, in later generations, of the bad from the good traits which a selected individual had carried; and to the speediest possible multiplication of the desirable characteristics, while at the same time the population would continue to show a high variability in all other respects. But the elaboration of this

field of science may be left for more specifically genetic treatises.

As for the continuance of this work in the more distant future, we may confidently leave it to the Darwins, Engelses, and Einsteins composing future generations not to botch the job, and, with each progressing generation, the increasing intelligence and comradeliness of men will make further progress ever surer, and will supply the means of coping with the increasingly advanced tasks that will then be before them. Thus we are not dealing with an institution whose activity would tend to become dulled or perverted in the course of time; for by its own fruits it would be not only proved, but also strengthened, provided we had started by stressing the two most indispensable ideals already mentioned.

Now all this is no idle dream. It not only certainly can be done—I believe it certainly will be done. Exactly how these applications of genetics will come to man may at present be in some dispute; but come they undoubtedly will. It is unthinkable that man will ever voluntarily relinquish his potential dominion, now that he has gone thus far. Nor will an enlightened world for ever reject any effective means for its own advancement. Not only is our genetic improvement patently possible, but it is far surer and more

feasible than any ultimate conquest of the atom, of interplanetary space, or of external nature in general, of the kind discussed in an earlier section. And even if our conquest of external nature fail, still we shall have conquered ourselves, and we may be content enough with the probable prospect of some hundreds of millions of years of happy endeavour in store for us on this planet.

But do not think that the picture above suggested—of a race of people all of whom come up to the level of what we now call " genius "—is likely to be anything more than the first, or (in terms of a longer view) the most immediate result. Consider once more what has happened along that long system of reproductive cords (see pages 27 to 32), which have by mere " trial and error " carried us organisms onward from the simplest bits of protoplasm like amœba, to eucalyptus trees, ants, elephants, or men and women. And then consider that our own red cord of change and fitfully accumulating advance has a chance of extending for at least as far again into the remote future. The cord, if prolonged only a foot beyond its present terminus, would carry us as far as the year 5000. But, in some of our laboratory animals, we have been able to accomplish as much in a decade or two, by the aid of genetics,

as nature could do in perhaps ten thousand years. If then, by natural processes, the cord has gone onward from the amœba all the way to man, why may it not well come to pass that in the course of an equal time, under the guidance of our own growing understanding and skill, our cord will have progressed ever so much farther beyond man than man has already gone beyond the amœba? I call on him who claims that man has reached a final form to tell me how the televisor, the automobile, the modern skyscraper may now be still further improved upon. Yet do we not know that a thousand years from now these will probably be utterly different in shape and structure, and that our inability to suggest advantageous changes now is due simply to the present limitations of our knowledge and our imaginations? In time to come, the best thought of the race will necessarily be focused on the problems of evolution—not of the evolution gone by, but of the evolution still to come—and on the working out of genetic methods, eugenic ideals, yes, on the invention of new characteristics, organs, and biological systems that will work out to further the interests, the happiness, the glory of the god-like beings whose meagre foreshadowings we present ailing creatures are.

And so we foresee the history of life divided into

three main phases. In the long preparatory phase it was the helpless creature of its environment, and natural selection gradually ground it into human shape. In the second—our own very short transitional phase—it reaches out at the immediate environment, shaking, shaping, and grinding it to suit better the form, the requirements, the wishes, and the whims of man. And in the long third phase it will reach down into the secret places of the great universe of its own nature and, by the aid of its ever-growing intelligence and co-operation, shape itself into an increasingly sublime creation—a being beside which the mythical divinities of the past will seem more and more ridiculous, and which, setting its own marvellous inner powers against the brute Goliath of the suns and planets, challenges them to contest.

Here you have one biologist's view of "progress." And perhaps I may add that there are other biologists who already have come to share this view. The biologist's view is the long view, covering æons composed of millions of years. By the standards of the man in the street he would appear crazy. But he has the evidence, he has seen the panorama, and he *knows* that life as a whole is ceaseless change, that the accomplishments even of *natural* evolution far surpass

any other type of progress that he could have imagined possible, and that there is no sign of a physical limit yet. There is no permanent *status quo* in nature; all is a process of adjustment and readjustment, or else eventual failure. But man is the first being yet evolved on earth which has the power to note this changefulness, and, if he will, to turn it to his own advantage. He can take the red cord of life, the thread of destiny, from the hands of Clotho, and spin it for himself.

The economic and material conditions of life are truly said to determine the behaviour and the social conditions of mankind. They can do this, of course, only by working through the mechanism of man himself; and thus it is because man is genetically what he is that history *can* take the course which it is taking. This is the fact that fatalists of the Oriental school overlook. The fact that man is already a creature of thought, of aspirations, of struggle, of the will-to-power is a *sine qua non* in the successful issue of his passage from the present darkness to the light that is dawning. Without mental eyes, he could not see this light, nor move in its direction. But he has these eyes, and through them he has the only sort of freedom that means anything. As they improve, there is a growing rôle for them and for the social

will-to-power which they serve, in the determination of his destiny. The mind of man must more and more become the master, not only of the outer material world, and so too of his social world, but also of the genetic thread of life within him. Thus there will come an ever greater freedom.

That which the " wisdom " of the past and the standards of the complacent elderly rulers of most of the world to-day regard as the most fixed and eternal verities: the class state, the church, the old-fashioned family and home, private property, rich and poor, " human nature " (to-day meaning mainly the private-profit motive), their own race, their heaven and their " immortal soul "—all this is patently evanescent. But that which the daring and the science of the young-minded realists (whether physically young or old) have projected as a practicable though never finished ideal—this becomes, as we watch, the ever more solid and substantial. It is in this sense of the ideal as the product of aspiration and of controlled creative imagination based on knowledge of the real material world, and as an object to be worked for, and not at all in the mystical sense of " philosophical idealism " or immaterial reality and pure contemplation, that the following poem of Edwin Markham, entitled " To Young America," but

really dedicated to mankind at large, should rightly be taken:

In spite of the stare of the wise and the world's derision,
Dare travel the star-blazed road, dare follow the Vision.

It breaks as a hush on the soul in the wonder of youth
And the lyrical dream of the boy is the kingly truth.

The world is a vapour, and only the Vision is real—
Yea, nothing can hold against Hell
but the Winged Ideal.

THE END